

MICROCOPY RESOLUTION TEST CHART NATIONAL BUREAU OF STANDARDS-1963-A

AD A 123115



PHASE III AND FINAL REPORT

FOR HIGH-RELIABILITY, LOW-COST INTEGRATED CIRCUITS

Prepared By RCA Solid State Divison Poute 202, Somerville, N.J. 08876

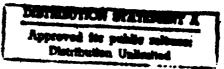
For

DEPARTMENT OF THE NAVY
NAVAL ELECTRONICS SYSTEMS COMMAND
Weshington, D.C.

Contract No. N00039-76-C-0240 Project No. 62762N Subproject No. XF54586 Task No. 002



Qualified requesters may/obtain coaies of this report from the Defense Documentation/Center, Cameron Station Alex., Va. 28316. his document is subject to pecial expect control and each transmitted to the period governments or foreign autonals may be made only with prior appropriate the Naval Electronic Systems Command, Washington, D.C. 20308.



82 11 05 035

TIL FILE COP

TABLE OF CONTENTS

Section	<u>Title</u>	Page
I	ABSTRACT	I-1
II	INTRODUCTION	11-1
III	ACCOMPLISHMENTS	111-1
IV	DETAILED DATA - TECHNICAL DISCUSSION	IV-1
	A. OBJECTIVES OF PHASE III	IV-1
	B. TEST PLAN	IV-1
	C. LIFE AND ENVIRONMENTAL TESTS	IV-i
	1. Operating and Bias-Life Tests	IV-1
	2. 150°C Storage-Life Tests	IV-18
	3. Bias/Humidity-Life Tests	IV-21
	4. Autoclave Tests	IV-21
	5. Salt-Atmosphere Tests	IV-24
	6. Thermal-Shock Tests	IV-26
	7. Temperature-Cycle Tests	IV-26
	8. Sequence Test No. 1	IV-29
	9. Sequence Test No. 2	IV-31
	10. Sequence Test No. 3	IV-31
	D. Computerized Data Analysis	IV-34
	1. General	IV-34
	2. Delta Analysis	IV-35
	3. Histogram	IV-35
	4. Trend Analysis	IV-40

;

Accession For

BTIS GRIAI

DTIG TAB

Unampoused

Justice

PP

Pistribetion/

Availability Codes

[avail and/or

Dist Special



LIST OF FIGURES

Fig.	<u>Title</u>	Page
IV-l	Phase III test plan.	IV-2
IV-2	CA741 125°C operating-life-test circuit.	IV-6
IV-3	CA741 250°C bias-life-test circuit.	IV-6
IV-4	CA74l bias/humidity-test circuit.	IV-7
IV-5	CD4012 125°C dynamic-life-test circuit. This circuit	
	may also be used for dynamic burn-in at 125°C, 168 hours.	IV-7
IV-6	Circuit used for CD4012 250°C bias life and 85°C/85% R.H.	
	bias/humidity test, inputs low.	1V-8
IV-7	Circuit used for 250°C bias life and 85°C/85% R.H. bias/	
	humidity test, inputs high.	IV-8
IV-8	5470 125°C operating-life-test circuit.	IV-9
IV-9	5472 125°C operating-life-test circuit.	IV-9
IV-10	54S20 125°C operating-life-test circuit.	IV-10
IV-11	54S20 250°C static-burn-in circuit.	IV-10
IV-12	Summary data histogram.	IV-39
TV-13	Trend analysis.	1 V-V I

LIST OF TABLES

Table	Title	Page
IV-1	Schedule of Down Times	IV-3
IV-2	Phase III Testing	IV-4
IV-3	125°C Operating-Life Test Summary	IV-5
IV-4	CA741 HRLC Accelerated Bias Life	IV-12
IV-5	CD4012 HRLC Accelerated Bias Life	IV-13
IV-6	54520 HRLC Accelerated Bias Life	IV-15
IV-7	54S2O Ceramic-Package Accelerated Bias Life	IV-16
IV-8	125°C Failure Rates	IV-17
IV-9	Accelerated-Life-Test Failure Rates	IV-19
IV-10	150°C Storage-Life Test Summary	IV-20
IV-11	85°C/85% R.H. Bias-Life Test Summary	IV-22
IV-12	Autoclave Test Summary	IV-23
IV-13	Salt-Atmosphere Test Summary	IV-25
IV-14	Thermal-Shock Test Summary	IV-27
IV-15	Temperature-Cycle Test Summary	IV-28
IV-16	Salt Atmosphere, 85°C Static-Life Test	
	Sequence (#1) Summary	IV-30
IV-17	Thermal Shock, 125°C Operating-Life Test	
	Sequence (#2) Summary	IV-32
IV-18	Thermal-Shock, Temperature-Cycle, Moisture-	
	Resistance Test Sequence (#3) Summary	IV-33
TV-10	Data Analysia	TV-36

SECTION I ABSTRACT

The objective of Phase III of this investigation was to demonstrate the reliability of the integrated circuits fabricated in Phase II according to the processes developed in Phase I (see Phase I and Phase II Final Development Reports for High-Reliability, Low-Cost Integrated Circuits, Contract No. N00039-76-C-0240). Devices were evaluated on the basis of a variety of life and environmental tests and the data recorded on magnetic tape for later retrieval and analysis. Computer software programs were developed to allow the data to be presented in a number of ways for evaluation and to allow the calculation of failure rates.

ACKNOWLEDGMENT

Support for this program was provided the RCA Solid State Division by the Naval Electronics Systems Command, Electronics Technology Division, ELEX 304, Washington, D.C. Technical direction was provided by the Naval Ocean Systems Center, Advanced Applications Division, Code 923, San Diego, California.

SECTION II INTRODUCTION

The objective of this program was to investigate alternate approaches to MIL-M-38510 for fabricating high-reliability integrated circuits at low cost. Emphasis was on adapting existing technology to industry mainstream products to achieve a semiconductor reliability that would meet military requirements without a severe cost penalty.

The approach to achievement of the goals of the program involved the integration and application of existing sealed-chip integrated-circuit processing with automated plastic packaging. The program was carried out in three phases.

A. Phase I

- Process Feasibility The required photomasks were generated using existing masks to the maximum extent possible. Then, small quantities of each device type were fabricated to assure that the masks and processes were available for the production runs of Phase II. Also, each device type was fabricated using a matrix of carefully varied process parameters whose impact on yields and reliability could be assessed.
- 2. Process Development The processes required to fabricate the integrated-circuit types to be produced in Phase II were defined and documented. Silicon nitride passivation and the titanium-platinum-gold metallization system were used to achieve chip hermeticity and a corrosion-free metallization system. In addition, a silicon nitride overcoat layer was applied for protection of the metallization. A series of experiments was completed at each critical processing step to assure repeatability. Real-time indicators and accelerated life tests were

used to assess the effects of process changes on reliability and to measure progress in achieving the required failure rate.

3. Automated Assembly - The technology to be used in Phase II was defined and documented. The effect of assembly process parameters on cost and yield was assessed. Bonding tapes and lead-frames compatible with each of the device types were designed and fabricated. A number of devices of each type were assembled using the automated assembly system. Reliability was monitored continually by means of accelerated life tests.

The photomasks, wafer process, and assembly process required to fabricate the integrated-circuit types in the low-cost high-reliability device-fabrication phase were defined and documented, and sample devices of each type were fabricated. Additionally, preliminary reliability data was generated to demonstrate the soundness of the chosen approach.

At this time, the production runs of Phase II were undertaken.

B. Phase II

The low-cost high-reliability device-fabrication phase of the program involved the fabrication of significant quantities of each of the selected integrated-circuit types according to the processes defined in Phase I. Both silicon nitride passivated, titanium-platinum-gold metallized integrated circuits and conventional silicon dioxide passivated, aluminum-metallized integrated circuits were constructed in both plastic and ceramic packages so that a comparison could be made between the new and conventional processes. The utilization of existing equipment and mask sets was demonstrated, and the cost impact of converting to this type of processing estimated. Preliminary reliability testing highlighted two problems areas: copper migration and beam-tape stress. Modifications to the packaging system were made which successfully resolved these problems.

All devices produced in this phase of the program were utilized in Phase III for reliability testing and delivery to the Navy. Finally, the testing facilities for the Phase III program were defined and assembled.

C. Phase III

In Phase III, the reliability of the devices produced in Phase II was demonstrated through operating-life tests, static-life tests, storage-life tests, moisture tests, thermal-cycling and sequence tests. All devices were serialized and data logged prior to the start of the tests and the information stored on magnetic tape. Data was similarly recorded at down periods and at the end of test. Software was generated to format this data in a variety of ways, and from this base the device failure rates were calculated.

SECTION III ACCOMPLISHMENTS

Data derived from Phase III of the program may be summarized as follows:

- o The reliability problems associated with beam-tape design and metallurgy in Phase II were successfully resolved and did not impact Phase III testing.
- o The failure rate at +125°C of the HRLC (high-reliability, low-cost) 54S20 low-power Schottky TTL circuit based on all the data available is estimated to be no greater than 0.0081%/1000 hours at 60% confidence to military limits.
- o The HRLC CA741 failure rate at +125°C based on accelerated test results is estimated to be no greater than 0.019%/1000 hours at 60% confidence to military limits. The difference between this failure rate and that for the 54820 is believed to be caused by voltage stress levels (5.5 V for the 54820 versus 30 V for the CA741.)
- o The HRLC CD4012 failure rate at $+125^{\circ}$ C based on accelerated test results is estimated to be no greater than 0.17%/1000 hours at 60% confidence to military limits.

SECTION IV

DETAILED FACTUAL DATA -- TECHNICAL DISCUSSION

A. Objectives of Phase III

During Phase III of this program to design and develop low-cost high-reliability integrated circuits, the reliability of the parts fabricated in Phase II according to processes developed in Phase I was demonstrated through a predetermined test plan which entailed extended life and environmental tests. Parametric data was taken and recorded at the start of each test, at subsequent down times, and at the termination of the test. All data was stored on magnetic tape and later used to calculate device failure rates.

B. Test Plan

The testing plan for the HRLC program is shown in Figure IV-1. The schedule of down times is shown in Table IV-1. The test plan has four distinct sections: life tests, moisture tests, thermal-cycle tests, and sequence tests. Each test is described and the data reviewed in the following sections. Table IV-2 summarizes the tests performed in Phase III and the test durations.

C. Life and Environmental Tests

1. Operating and Bias-Life Tests

The operating and bias-life tests were based on MIL-STD-883B,
Method 1005.2. 125°C operating-life tests were carried out to 5,000 hours
on six different plastic-packaged device types. The results are summarized
in Table IV-3. Life-test circuits are shown in Figures IV-2 through IV-11.

SEQUENCE TESTS ²	24-Hour Salt Atmosphere Plus 160-Hour 85°C Static Life HRLC DIP HRLC DIC 15 5	50-Cycle -65°C to +150°C Thermal Shock Plus 160-Hour 125°C Operating Life HRLC DIP 20 5	15-Cycle, -65°C to +150°C Thermal Shock Plus 10-Cycle -65°C to +150°C Temperature Cycle Plus 10-Day Moisture Resistance HRLC DIP ARLC DIP 10
SCREENED UNITS MOISTURE TESTS ²	Conditions HRLC DIP HRLC DIC 85°C/85% RH 45 15	Conditions HRLC DIP HRLC DIC 15 PSIG 30 10	Conditions HRLC DIP HRLC DIC MIL 1009.1 20 10 THERMAL-CYCLE TESTS Conditions HRLC DIP HRLC DIC 5°C to 150°C 20 5 (Liqto-Liq.) TEMPERATURE CYCLES Conditions HRLC DIP FRLC DIC 5 (Liqto-Liq.) TEMPERATURE CYCLES Conditions HRLC DIP HRLC DIC 5 (Liqto-Liq.)
LIFE TESTS	Operating Life CA741, 5420, 54820,5470, 5472 Temp (°C) HRLC DIP 125	Operating Life CD4012 Temp (°C) HRLC DIP 125 300	STATIC LIFE CD40121, CA7411, 54820 Temp (°C) HRLC DIP HRLC DIC 150 30 30 175 30 30 200 30 30 225 30 30 250 30 30 STORAGE LIFE CD4012, CA741, 54820 Temp (°C) HRLC DIP 150 25

A. P. A. P. AND STREET, A. L. P. L. P. L. P. L. P. S. P. L. P. L.

Fig. IV-1 - Phase III test plan.

Performed during Phase II.
 Moisture, Sequence, and Thermal-Cycle tests were conducted on a three-type mix in quantities shown: CA741, CD4012, 54S20.

Table IV-1 - Schedule of Down Times

Test		Down Time for Electrical Test
Operating Life	125°C	168,1000,2000,5000 Hours
Static Life	150°C	168,500,2000,5000 Hours
Static Life	175°C	168,500,2000,5000 Hours
Static Life	200°C	48,168,250,500,1000,2500 Hours
Static Life	225°C	48,168,250,500,1000,2500 Hours
Static Life	250°C	12,48,96,168,500,1000 Hours
Storage Life	150°C	168,500,2000,5000 Hours
Humidity Bias Life	85°C/85% RH	168,500,1000,2500 5000 Hours
Pressure Cooker	15 PSIG	48,96,200 Hours
Salt Atmosphere		24,96 Hours
Thermal Shock -65°C	c to 150°C	100,500,1000,2000 Cycles
Temperature Cycle -	·65°C to 150°C	100,500,1000,2000 Cycles
Sequence Test 1		1,2,3 Cycles
Sequence Test 2		1,2,3 Cycles
Sequence Test 3		1,2,3 Cycles

Note: Sequence tests are as follows:

- 1. Salt atmosphere plus bias life.
- 2. Thermal shock plus operating life.
- Thermal shock plus temperature cycle plus moisture resistance.

Table IV-2 - Phase III Testing (Hours or Cycles Completed)

	CA741	CD4012	5420	5470	5472	54820
125°C Operating-Life Test - Hrs. Static-Life Test - Hrs.	5000 NA	5000 NA	5000 NA	5000 NA	5000 NA	2000
150°C						2000
175°C						4700
200°C						2500
225°C						2500
250°C						1000
150°C Storage-Life Test - Hrs.	2000	2000	NA	NA	NA	2000
85°C/85% RH Bias-Life Test - Hrs.	2000	2500	NA	NA	NA	2000
15 psig Autoclave - Hrs.	200	200	NA	NA	NA	200
Salt Atmosphere - Hrs.	96	96	NA	NA	NA	96
Thermal Shock - Cycles	2000	2000	NA	NA	NA	2000
Temperature Cycle	2000	2000	NA	NA	NA	2000
Salt Atmosphere + 160 Hr., 85°C	m	e	NA	NA	NA	က
Static-Life Test - Cycles						
Thermal Shock + 160 Hr., 125°C	က	9	NA	NA	NA	က
Operating-Life Test - Cycles						
Thermal Shock + Temperature Cycle	e	က	NA	NA	NA	က
+ Moisture Resistance - Cycles						

Table IV-3 - 125°C Operating-Life Test Summary

Number of Devices Exceeding Specified Limits
(Mil = Mil 38510/Limits
Comm = Commercial Data Sheet
Inop = Inoperable)

Notes:

- Device #106 burned up on rack. Failure analysis indicates electrical overstress.
- CD4012 Five units. All fail at 1000 hrs. #192, 179 and 285 fail I_{SS} . #67 and 84 fail multiple parameters. Device #67 had a Pin 7 to Pin 13 NMOS gate-oxide short. Failure analysis indicates oxide nonuniformity. Device #84 had a Pin 3 to Pin 1 Note: gate-oxide short. Failure analysis indicated electrical overstress. failures were checked on 4-15-80; the devices recovered.
- CD4012 Four units, all fail at 2000 hrs. #18, #141, failed Iss, #206 failed IIH2. #222 failed Iss + multiple.

IV-5

- Multiple failure. Failure analysis indicates external lead-frame short. Device #90.
- Device was operative at all Device #100 failed some truth-table functional tests at 1000 hours. Unit recovered after overnight bake at 150°C and was put back on test. subsequent down times. ۶.

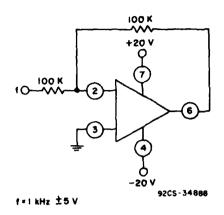


Fig. IV-2 - CA741 125°C operating-life-test circuit.

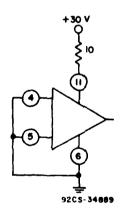


Fig. IV-3 - CA741 250°C bias-life-test circuit.

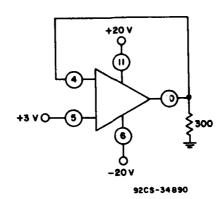
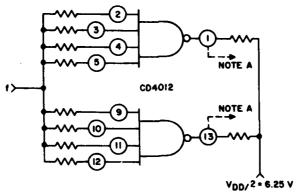


Fig. IV-4 - CA741 bias/humidity-test circuit.



V_{DD}=12.5 V, PIN 14 V_{SS}=GND, PIN 7

f = 50 kHz, 0 TO 12.5 V, SQUARE WAVE, 50 % DUTY CYCLE, t_f=t_f ≤ 1 µs RESISTORS = 47 K

NOTE A: FOR LONG-TERM LIFE TESTS (>2000 HOURS), THE OUTPUTS OF ONE DEVICE MAY BE USED TO DRIVE THE NEXT DEVICE ON THE BOARD.

Fig. IV-5 - CD4012 125°C dynamic-life-test circuit. This circuit may also be used for dynamic burn-in at 125°C, 168 hours.

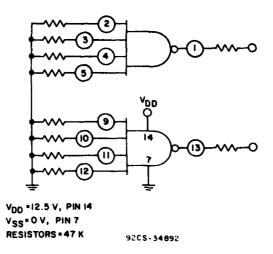


Fig. IV-6 - Circuit used for CD4012 250°C bias life and 85°C/85% R.H. bias/humidity test, inputs low.

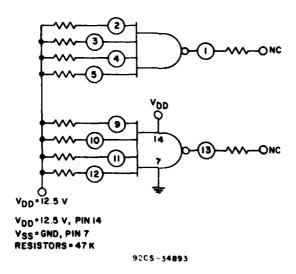
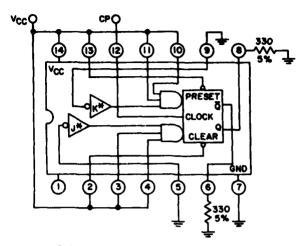


Fig. IV-7 - Circuit used for 250°C bias life and 85°C/85% R.H. bias/humidity test, inputs high.



 V_{CC} = 5 V CP = 100 kHz, SQUARE WAVE, 5.5 V, 50% DUTY CYCLE T_A = +125°C OUTPUT = 3 $V_{\rm D-D}$

92CS-34894

Fig. IV-8 - 5470 125°C operating-life-test circuit.

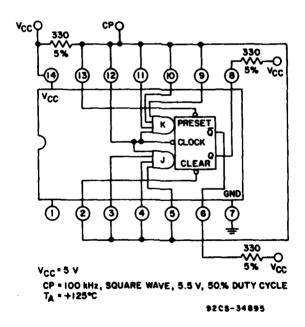


Fig. IV-9 - 5472 125°C operating-life circuit.

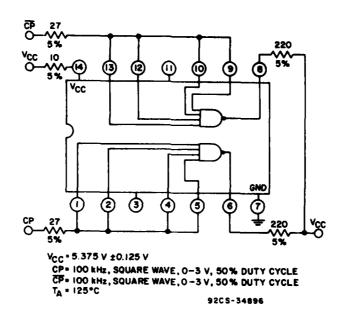


Fig. IV-10 - 54S20 125°C operating-life-test circuit.

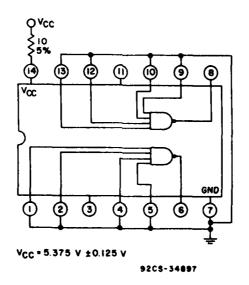


Fig. IV-11 - 54S20 250°C static-burn-in circuit.

- a. <u>CA741</u> The test sample for the CA741 consisted of 150 devices on 125°C operating-life test. Two early parametric failures occurred at 168 hours. These units recovered after a 48-hour, 150°C bake. The failure mechanism was attributed to mobile ion contamination. A third failure occurred at 5,000 hours, the final down time. Failure analysis indicated electrical overstress. Phase II bias-life tests had few failures from 150°C to 225°C; see Table IV-4. At 250°C, the predominant failure mode was bondbeam breaks. These were corrected before the start of Phase III with a new tape layout.
- b. <u>CD4012</u> The test sample for the CD4012 consisted of 300 devices on 125°C operating-life test. There were failures to the military limits at each down time. The number of failures decreased dramatically after 2,000 hours. The same phenomenon had occurred in Phase II on 150°C bias life (Table IV-5). In addition, the number of failures on 150°C, 175°C, 200°C, 225°C, and 250°C bias-life tests run in Phase II were relatively independent of temperature.

As previously noted, the military limits on these devices are very severe and may have caused the erratic results. A decision was made to restrict the failure-analysis effort to commercial limit and to inoperative failures, of which there were a total of nine.

c. 5420 - The test sample for the 5420 consisted of 150 devices. One failure occurred at 2,000 hours, and was attributed to a lead-frame short; the short was external to the silicone body. There were no additional failures out to the final down time.

Table IV-4 - CA741 HRLC Accelerated Bias Life at 30V

			Number of	Devic	es Excee	ding Mil-	-Std a	nd Comm	Devices Exceeding Mil-Std and Commercial Limits at Each Down Time	nits a	t Each Do	wn Time		
	250°C	250°C (N=28)	22	25°C (N=29)	1=29)	200	S (N	30)	175	C (N=	30)	150	150°C (N=30)	30)
Hrs.	MII	8	Hrs.	H	S	Hrs.	rs. Mil Com	S	Hrs.	rs. Mil Com	CO	Hrs.	ME1	8
7	0	0	7	0	0	7	٣	က	œ	0	0	∞	0	0
4	0	0	7	0	0	4	0	0	24	0	0	77	0	0
00	0	0	00	-	0	∞	0	0	168	0	0	168	0	0
16	0	0	16	0	0	16	0	0	336	0	0	200	0	0
32	4	m	32	0	0	32	0	0	672	0	0	1000	0	0
64	'n		79	0	0	99	0	0	1000	0	0	1500	0	0
128	9	m	128	0	0	128	0	0	2000	0	0	2000	0	0
256	13	m	256	-	-	256	-	0	3024	0	0	2500	0	0
512	0	m	454	0	0	512	0	0	4000	0	0	4000	0	0
1500	-	4	1500	0	0	992	0	0	2000	0	0	2000	0	0
									J 6024	0	0	7064	0	0
									10,000	0	0			
Total 27	1 27	17		7	-		4	ъ		0	0		0	0

II sasdq

Phase III

Table IV-5 - CD4012 HRLC Accelerated Bias Life at 12.5V

Number of Devices Exceeding Mil-Std and Commercial Limits at Each Down Time

I	Ι	98	вų	ď			l		11	Ί	98	Ррв
0	0	0	0	0	0	0	0	0	0	0	0	0
7	7	7	-	0	0	0	0	0	0	0	0	0
œ	24	168	200	1000	1500	1836	3012	4012	6052	8112	10012	12028
							L					
-	0	0	0	0	0	0	0	0	0	0	-	0
4	0	0	0	0	0	0	-	0	0	7	-	0
∞	24	168	336	672	1000	1344	1680	2000	2520	3020	4004	6020
0		0	0	0	0	-	0	7	7	_		
7	-	0	0	-	-	4	2	m	0	0		
7	4	00	16	32	9 9	128	256	424	880	1336		
0		0	0		0	0	0	4	7	-		
ო	7	0	_	m	0	4	က	0	-	-		
7	4	00	16	32	99	128	256	454	880	1500		
0	0	0	0	7	0	٣	7	0	4	0		
-	-	-	4	7	2	~	-	-	4	0		
7	4	œ	91	32	64	128	256	474	880	1048		
	2 1 0 2 3 0 2 2 0 8 4 1 8 2 0 H	4 1 8 2 0 0 0 24 2 0	4 1 8 2 0 0 0 24 2 0 0 0 168 2 0	1 0 2 3 0 2 2 0 8 4 1 8 2 0 1 0 4 2 1 4 1 1 24 0 0 24 2 0 1 0 8 0 0 168 0 0 168 2 0 4 0 16 1 0 16 0 0 336 0 0 500 1 0	1 0 2 3 0 2 2 0 8 4 1 8 2 0 1 0 4 2 1 4 1 1 24 0 0 24 2 0 1 0 8 0 0 168 0 0 168 2 0 4 0 16 1 0 16 0 0 500 1 0 2 1 32 3 1 32 1 0 672 0 0 1000 0 0	1 0 2 3 0 2 2 0 8 4 1 8 2 0 1 0 4 2 1 4 1 1 24 0 0 24 2 0 1 0 8 0 0 168 0 0 168 2 0 4 0 16 1 0 16 0 0 336 0 0 500 1 0 2 1 32 3 1 32 1 0 672 0 0 1000 0 0 0 0 5 0 64 0 0 64 1 0 1000 0 0 1500 0 0 0	1 0 2 3 0 2 2 0 8 4 1 8 2 0 1 0 4 2 1 4 1 1 24 0 0 24 2 0 1 0 8 0 0 168 0 0 168 2 0 4 0 16 0 0 168 0 0 168 2 0 2 1 32 3 1 32 1 0 672 0 0 1000 0 5 0 64 0 0 64 1 0 1000 0 0 1500 0 0 1 3 128 4 0 1344 0 0 1836 0 0	1 0 2 3 0 2 2 0 8 4 1 8 2 0 1 0 4 2 1 4 1 1 24 0 24 2 0 4 0 8 0 0 168 0 0 168 2 0 4 0 16 0 0 168 0 0 168 0 0 2 1 3 1 32 1 0 672 0 0 1000 0 0 5 0 64 0 64 1 0 1000 0 1500 0 0 1 3 128 4 0 1334 0 0 1836 0 0 1 2 256 3 0 256 5 0 1680 1 0 0 0	1 0 2 3 0 2 2 0 8 4 1 8 2 0 1 0 4 2 1 4 1 1 24 0 24 2 0 4 0 8 0 0 168 0 0 168 2 0 4 0 16 1 0 16 0 0 168 0 0 168 2 0 2 1 3 1 32 1 0 672 0 0 1000 0 0 0 5 0 64 0 64 1 0 1000 0 0 1500 0 0 1 3 128 4 0 128 4 1 1344 0 0 1836 0 0 1 2 256 3 0 256 5 0 1680 0 0 4012 0 0 1 0 424 3 2 2000 0 4012 0 0	1 0 2 3 0 2 2 0 8 4 1 8 2 0 1 0 4 2 1 4 1 1 24 0 0 24 2 0 4 0 8 0 0 168 0 0 168 2 0 4 0 16 1 0 168 0 0 168 2 0 2 1 0 168 0 0 1000 0 1 0 5 0 64 0 0 672 0 0 1 0 0 5 0 64 0 0 64 1 0 1000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2 0 8 4 1 8 2 0 1 1 24 0 0 24 2 0 0 0 168 0 0 168 2 0 0 0 336 0 0 1000 1 0 1 0 1000 0 0 0 0 0 4 1 1344 0 0 1836 0 0 5 0 1680 1 0 4012 0 0 3 2 2520 0 0 6052 0 0 0 1 3020 2 0 0 0 0	1 0 2 3 0 2 2 0 8 4 1 8 2 0 1 0 4 2 1 4 1 1 24 0 0 24 2 0 4 0 8 0 0 168 0 0 168 2 0 4 0 16 0 168 0 0 168 2 0 2 1 0 16 0 0 1000 0 1 0 5 0 64 1 0 672 0 0 1500 0 0 1 2 256 3 0 256 5 0 1680 1 0 0 4 4 4 4 4 4 1 0 0 0 0 0 1 0 0

(a) 7 units removed: 3 broken pins, 4 Vss diode

0

∞

œ

17

18

10

Total 21

- d. $\underline{5470}$ The test sample for the 5470 consisted of 150 devices. There were no failures out to 5,000 hours.
- e. 5472 The test sample for the 5472 consisted of 144 devices. One device failed some truth-table functional tests at 1,000 hours. This unit recovered after an overnight bake at 150° C and was put back on test. The device passed at all subsequent down times. There were two additional parametric failures at the 5,000-hour down time.
- f. 54820 The 125°C life-test sample for the 54820 consisted of 150 devices. There were no failures on this test out to 5,000 hours. In addition, bias-life tests were run at five different temperatures for both plastic and ceramic devices. At each temperature, 30 plastic devices and 30 ceramic devices were tested. On the 150°C, 175°C, 200°C, and 225°C tests there were no failures in either the plastic or ceramic-packaged devices (see Tables IV-6 and IV-7.) However, on the 225°C test, the plastic cell had four military limit failures. All four occurred at the 2,500-hour down time. The ceramic cell had one military limit failure on this test. It also occurred at the 2,500-hour down time. On the 250°C test, there were four military limit failures at 12 hours. An additional military limit failure occurred at 500 hours. There were no additional failures through the final 1,000-hour down time. Failure analysis on all five devices indicated Schottky-diode leakage. There were no failures in the ceramic-packaged devices on the 250°C test.
- g. Failure-Rate Calculations Failure rates for the various integrated circuits based on 125°C operating-life testing are shown in Table IV-8. As noted in the original contract proposal, 40-million device-hours with one failure would be required to meet the stated goal of 0.005%/1,000 hours. The difficulty of this goal is demonstrated in the case of the 5420, the 5470, and the 54820, for which no failures occurred in the course of the 5,000-hour life test; however, the calculated failure rate is 0.12%/1000 hours.

i

Table IV-6 -54S20 HRLC Accelerated Bias Life at 5.5V

Number of Devices Exceeding Specified Limits at Each Down Time

- •	250°C ((N=30)		5°C (N=	130)	200,	SC (N	30)	175	N)	30).	150	ž) J	30)
Hrs.	Ħ	M11 Inop	Hrs	M11 Inop	Inop	Hrs.	s. Mil Inop	Inop	Hrs.	s. Mil Inop	Inop	Hrs.	irs. Mil Inop	Inop
	*7	0		0	0	87	0	0	168	0	0	168	0	0
	0	0	168	0	0	168	0	0	200	0	0	200	0	0
	0	0		0	0	250	0	0	2000	0	0	2000	0	0
	0	0		0	0	200	0	0	4700	0	0	2000	0	0
	*.	0		0	0	1000	0	0						
	0	o ,		4	0	2500	0	0						
Total	5	0		4	0		0	0		0	0		0	0

*All 5 devices failed IIH, (for different inputs). The limit is 50 uA and devices vary from 64.9 to 99.6 uA. Failure analysis indicates Schottky diode leakage.

Table IV-7 - 54S20 Ceramic-Packaged Accelerated Bias Life at 5.5V

			Num	ber of	Devices	Exceedi	ng Sp	ecified	Limits at	Each	Number of Devices Exceeding Specified Limits at Each Down Time			
. •	250°C ((N=30)	22	2°C (N	=30)	200	S)	=30)	175	ر (N	:30)	150	N) 0	30)
	¥11	Mil Inop	Hrs.	s. Mil Inop	Inop	Hrs.	Mil	Irs. Mil Inop	Hrs.	Mil	s. Mil Inop	Hrs.	s. Mil Inop	Inop
	0	0	48	0	0	87	0	0	168	0	0	168	0	0
8 7	C	0	168	0	0	168	0	0	200	0	0	200	0	0
96	0	0	250	0	0	250	0	0	2000	0	0	2000	0	0
168	0	0	200	0	0	200	0	0	4700	0	0	2000	0	0
200	c	0	1000	0	0	1000	0	0						
1000	Ó	6	2500	-	0	2500	0	0						
Total	0	0		-	0		0	0		0	0		0	0

Table IV-8 - Failure Rates from 125°C Testing

				No.	No. of Failures	S			
			No. of	(Less O	verstress 6	Mech.)	(2/100)	00 Hrs.	@60% Conf)
Type	No. of Devices	No. of Hrs.	Device Hrs.	Mil	Mil Comm Limit Limit Inop	Inop	Mil	Comm	Limit Comm
CA741	150	2000	750,000	2	2	0	0.41	0.41	0.12
CD4012	300	2000	1,500,000	21	%		1,50	0.62	0.13
5420	150	2000	750,000	0	0	0	0.12	0.12	0.12
5470	150	2000	750,000	0	0	0	0.12	0.12	0.12
5472	150	2000	750,000	٣	٣	-	0.58	0.58	0.28
54820	150	2000	750,000	0	0	0	0.12	0.12	0.12

Accelerated life tests at temperatures ranging from 150°C to 250°C were conducted in Phase II and Phase III of the contract on three types to establish an adequate data base on which to predict failure rates. This data is shown in Table IV-9. Failures on the CA741 and CD4012 at 250°C, which were the result of beam-tape breaks which a subsequent redesign rectified, are not included in the failure statistics. As expected, the 54S20 exhibited the lowest failure rate of the three devices. This success is ascribed to the low voltage which is characteristic of the operation of this type of circuit. The predicted failure rate of the CA741 based on 44,700,000 equivalent device hours at 225°C to military limits is 0.019%/1,000 hours. The CMOS part criticized to military limits exhibited a failure rate of 0.17%/1,000 hours. The primary failure indicators were I_{LL}, whose limits were exceeded by 1 to 10 nanoamperes. The failure rate based on commercial limits is predicted to be 0.063%/1,000 hours.

2. 150°C Storage-Life Tests

The 150°C storage-life tests are based on MIL-STD-883B, Method 1008.1, Condition C. 150°C storage-life tests were performed on three types to 5,000 hours. Both plastic and ceramic samples were run on each type. The sample size for each type was 30 plastic and 30 ceramic. The results are summarized in Table IV-10.

- a. <u>CA741</u> Storage-life tests on the CA741 started in Phase II and continued in Phase III. Total hours accumulated were 5,000, with no failures in either plastic or ceramic-packaged devices.
- b. <u>CD4012</u> Storage-life tests on the CD4012 started in Phase II and continued in Phase III. Total hours accumulated were 5,000, with no failures in either plastic or ceramic-packaged devices.

Table IV-9 - Accelerated-Life-Test Failures Rates

	Temp.	Device Hrs.	Accel.(1) Factor	Equiv. Device Hr. @125°C	Mil Limit Failures	Comm. Limit Failures	λ(2) Míl Limits	λ(2) Comm Limits
CA741(5)	250°C 225°C 200°C 175°C	42,000 43,500 29,760 300,000	2110 621 160 35.7	88.6x106 27.0x106 4.8x106 10.7x106	27(4) 2 4 0	17(4)		
CA4012(5)	150°C 125°C Total 250°C 225°C 220°C	211,920 750,000 - 31,440 45,000	6.64 1.0 - 2110 621 160	1.41×10° 0.75×106 44.7×106 66.3×106 27.9×106 6.4×106	0 2 8 21(4) 18	0 2 6 10(4) 9	610.	.014
	175°C 150°C 125°C Total	180,600 360,840 1,500,000	35.7 6.64 1.0	6.4x106 2.4x106 1.5x106 44.6x106	21 21 72	. 7 9 7 8 8 7 8	0.17	0.063
54820	250°C 225°C 200°C 175°C 150°C 125°C	30,000 75,000 75,000 141,000 150,000 750,000	2100 621 160 35.7 6.64 1.0	63.3×106 46.6×106 ;2.0×106 5.03×106 1.00×106 0.75×106	N40000	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0.0081	0.00077(3)

1.lev activation energy. 2/1000 Hrs. @ 125°C, 60% confidence. Not criticized to commercial limits, inoperatives.

Failures due to beam breaks, corrective action implemented in Phase III. 4 4 4 4 4

Phase II tests.

Table IV-10 - 150°C Storage-Life Test Summary, Number of Devices Exceeding Mil Std. and Commercial Limits

PLASTIC

		741 * =30	CD46	01 2* 30	54S N=	20 25
Hours	Mil	Comm	Mi1	Comm	Mil	Comm
168	0	0	0	0	0	-
500	0	0	0	0	0	-
1000	0	0	0	0	0	-
2000	0	0	0	0	0	-
5000	0	0	0	0	0	-
Total	0	0	0	0	0	-

CERAMIC

	CA741*		CD40	012*	54820		
	N=	=30	N=:	30	N-	5	
Hours	<u>M11</u>	Comm	<u>M11</u>	Comm	<u>M11</u>	Comm	
168	0	0	0	0	0	-	
500	0	n	0	0	0	-	
1000	0	0	0	0	0	-	
2000	0	0	0	0	0	-	
5000	0	0	0	0	0	-	
Total	0	0	0	0	0	-	

^{*}Phase II devices continued in Phase III.

c. <u>54820</u> - Storage-life tests on the 54820 were run in Phase III. Total hours accumulated were 5,000, with no failures in either plastic or ceramic-packaged devices.

3. Bias/Humidity-Life Tests

Bias/humidity tests at 85°C and 85% relative humidity were carried out to 5,000 hours on types CA741 and 54S20 and to 2,500 hours on type CD4012. Both plastic and ceramic samples were run on each type. The data for these tests is summarized in Table IV-11.

- a. <u>CA741</u> The test sample for the type CA741 consisted of twelve plastic and four ceramic devices. The plastic sample experienced two parametric failures, one at 500 hours and one at 1,000 hours. The ceramic cell suffered one inoperative failure at 2,500 hours; the package lost hermeticity and experienced an arc-over at a base-to-emitter junction.
- b. <u>CD4012</u> The test sample for the type CD4012 consisted of eleven plastic and four ceramic devices. The plastic sample experienced one parametric failure at 500 hours and one at 1,000 hours. At 2,500 hours there were two additional parametric failures and two inoperative failures. There were three parametric failures in the ceramic cell at 500 hours.
- c. 54S20 The test sample for the type 54S20 consisted of eleven plastic and four ceramic devices. There were no failures in either cell.

4. Autoclave Tests

Autoclave tests were carried out at 15 psig to 200 hours on types CA741, CD4012, and 54S20. Both plastic and ceramic groups were run. The data for these tests is summarized in Table IV-12.

Table IV-11 - 85°C/85% R.H. Bias-Life Test Summary

PLASTIC

	CA741			(CD4012	2		54820			
		N=12			N=11			N=11			
Hours	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop		
168	0	0	0	0	0	0	0	0	0		
500	1	1(1)	0	1	0	0	0	0	0		
1000	1	1(1)	0	1	i	0	0	0	0		
2500	0	0	0	4	3	2(2)	0	0	0		
5000	0	0	0				0	0	0		
Total	2	2	0	6	4	2	0	0	0		

CERAMIC

		CA74	1	•	CD401:	2	54S N=	
Hours	Mil	Comm	Inop	Mil	Comm	Inop		mm Inop
168	0	0	0	0	0	0	0 0	0
500	0	0	0	3	0	0	0 0	0
1000	0	0	0	0	0	0	0 0	0
2500	1	1	1(3)	0	0	0	0 0	0
5000	0	0	0	-	-	-	0 0	0
Total	1	1	1	3	0	0	0 0	0

- 1. Number 153 failed CMRR and -PSRR at 500 hrs. Device recovered after a 4 hr. bake at 150°C. Device was put back up and failed again at 1000 hrs. Number 156 also failed at 1000 hrs. Device failed VIO, IIB and CMRR. Neither unit was baked at 1000 hrs. Both were put back up and run to 5000 hours.
- 2. One device, #308, recovered after a 150°C bake.
- 3. Unit #2 arc-over at BE junction. Package lost hermeticity.

Table IV-12 - Autoclave Test Summary (P = 15 PSIG T = 125°C)

PLASTIC

			CA741	1		CD401	12		54820	C	
	Hours	Mil	N=8 Comm	Inop	Mil	N=8 Comm	Inop	M11	N=7 Comm	n Inop	
	48	0	0	0	0	0	0	0	0	0	
	96	0	0	0	0	0	0	0	0	0	
	200	0	0	0	0	0	0	0	0	0	
Tota	1	0	0	0	0	0	0	0	0	0	

CERAMIC

	CA741		(D401	2		54820			
			N=3			N=3			N=2	
	Hours	Mil	Comm	Inop	M11	Comm	Inop	Mil	Comm	Inop
	48	0	0	0	0	0	0	0	0	0
	96	0	0	0	0	0	0	0	0	0
	200	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	0	0	0	0	0

- a. <u>CA741</u> The test sample for the type CA741 consisted of eight plastic and three ceramic devices. There were no failures in either cell.
- b. <u>CD4012</u> The test sample for the type CD4012 consisted of eight plastic and three ceramic devices. There were no failures in either cell.
- c. 54S20 The test sample for the type 54S20 consisted of seven plastic and two ceramic devices. There were no failures in either cell.

5. Salt-Atmosphere Tests

Salt-atmosphere tests were performed to MIL-STD-883B, Method 1009.2, Condition C, and were carried out to 96 hours on types CA741, CD4012, and 54S20. Both plastic and ceramic groups were run. The data for these tests is summarized in Table IV-13.

- a. <u>CA741</u> The test sample for the type CA741 consisted of five plastic and three ceramic devices. There were no failures in the plastic cell. The ceramic cell had one parametric failure (device No. 9) at 96 hours. Device leads were scraped, but the unit failed retesting. The leads were then ultrasonically cleaned in a water and detergent solution and scraped at the body of the device (to remove gold contamination between the leads). The device then recovered.
- b. <u>CD4012</u> The test sample for the type CD4012 consisted of five plastic and two ceramic cells. There were no failures in the plastic cell. The ceramic cell experienced one parametric failure (device No. 10) at 96 hours. Failure analysis is the same as that for the CA741 failure described in the paragraph above.

Table IV-13 - Salt-Atmosphere Test Summary

PLASTIC

		CA74	l	(CD401	2		54820)	
		N=5			N=5			N=5		
Hour	s Mil	Comm	Inop	M11	Comm	Inop	<u>M11</u>	Com	Inop	
24	0	0	0	0	0	0	-	0	0	
96	0	0	0	0	0	0	0	0	0	
Total	0	0	0	0	0	0	0	0	0	

CERAMIC

		CA74	1		CD401	2	!	54520	
		N=3	3		N=2			N=2	
Hours	<u>M11</u>	Com	Inop	<u>M11</u>	Comm	Inop	<u>M11</u>	Comm	Inop
24	0	0	0	0	0	0	0	0	0
96	1	1(1	0 0	1	1(2)	0	0	0	0
Total	1	1	0	1	ı	0	0	0	0

- 1. One unit (#9) failed multiple parameters at 96 hours. After scraping leads and retesting, unit still failed. After ultrasonically cleaning leads in water and detergent solution and scraping leads at the body of the device (to remove gold contamination between the leads) the unit recovered.
- 2. The unit (#10) failed for multiple parameters at 96 hours.

c. $\underline{54820}$ - The test sample for the type 54820 consisted of five plastic and two ceramic devices. There were no failures in either cell.

6. Thermal-Shock Tests

Thermal-shock tests were performed at -65°C to +150°C based on MIL-STD-883B, Method 1011.2, Condition C, and run to 2,000 cycles on types CA741, CD4012 and 54S20. The data for these tests is summarized in Table IV-14.

- a. CA741 The test sample for the type CA741 consisted of five plastic and two ceramic devices. There were no failures in either cell.
- b. <u>CD4012</u> The test sample for the type CD4012 consisted of five plastic and one ceramic device. There were no failures in either cell.
- c. 54S20 The test sample for the type 54S20 consisted of five plastic and one ceramic device. There were no failures in either cell.

7. Temperature-Cycle Tests

Temperature-cycle tests were performed at -65°C to +150°C based on MIL-STD-883B, Method 1010.3, Condition C, and run to 2,000 cycles on types CA741, CD4012, and 54S20. The data for these tests is summarized in Table IV-15.

a. <u>CA741</u> - The test sample for the type CA741 consisted of five plastic and three ceramic devices. There was one inoperative plastic device at 1,000 cylces. No ceramic devices failed.

Table IV-14 - Thermal-Shock Test Summary

PLASTIC

			CA74 N=5	-	(D401 N=5	.2		54S20 N=5	
	Cycles	Mil	Comm	Inop	Mil	Comm	Inop	<u>M11</u>	Comm	Inop
	100	0	0	0	0	0	0	0	0	0
	500	0	0	0	0	0	0	0	0	0
	1000	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	0	0	0	0	0

	CA741		(CD401	2	54\$20			
		N=2			N=1			N=1	
Cycles	<u>M11</u>	Comm	Inop	MIL	Comm	Inop	Mil	Comm	Inop
100	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

Table IV-15 - Temperature-Cycle Test Summary

PLASTIC

	CA741				CD40			54820			
		N=5	1		N=5	•		N=5			
Cycles	Mil	Comm	Inop	M11	Comm	Inop	M11	Comm	Inop		
100	0	0	0	0	0	0	0	0	0		
500	0	0	0	0	0	0	0	0	0		
1000	1	1	1(1)	0	0	0	0	0	0		
2000	0	0	0	0	0	0	0	0	0		
Total	1	1	1	0	0	0	0	0	0		

CERAMIC

		CA74	1		CD40	012		5482	:0
		N=3			N=]	l		N=1	
Cycles	Mil	Comm	Inop	Mil	Com	Inop	Mi1	Comm	Inop
100	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0
2000	0	0	0	1	0	0	1	0	0
Total	0	0	0	1	0	0	1	0	0

1. Device #112 failed for continuity on Teradyne Test Set.

Not verified in failure analysis. Device has been lost.

- b. CD4012 The test sample for the type CD4012 consisted of five plastic and one ceramic device. There were no failures in the plastic cell. The ceramic device was a parametric failure at 2,000 cycles.
- c. 54S20 The test sample for the type 54S20 consisted of five plastic and one ceramic device. There were no failures in the plastic cell. The ceramic device was a parametric failure at 2,000 cycles.

8. Sequence Test No. 1

Sequence test No. 1 consists of 24 hours of salt atmosphere plus 160 hours of 85°C static life. Three complete cycles of this sequence test were run on types CA741, CD4012 and 54S20. The data is summarized in Table IV-16.

- a. <u>CA741</u> The test sample for the type CA741 consisted of four plastic and two ceramic devices. There were no failures in either group.
- b. <u>CD4012</u> The test sample for the type CD4012 consisted of four plastic and two ceramic devices. There were no failures in the plastic cell. The ceramic cell experienced one parametric failure at the second cycle.
- c. 54820 The test sample for the type 54820 consisted of four plastic and one ceramic device. There were no failures in the plastic cell. The ceramic device was an inoperative failure at the first cycle. The device failed because of metal migration on the lead-frame external to the body of the device.

Table IV-16 - Salt-Atmosphere +85°C Static-Life-Test Sequence (#1) Summary

PLASTIC

		CA741		(CD401	2		54\$20				
			N=4			N=4			N=4			
<u>C</u>	ycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	L Comm	Inop		
	1	0	0	0	O	0	0	0	0	0		
	2	0	0	0	0	0	0	0	0	0		
	3	0	0	0	0	0	0	0	0	0		
Total		0	0	0	0	0	0	0	0	0		

	CA741		1	CD4012			54820			
	N=2				N=2			N=1		
Cycles	Mil	Comm	Inop	MII	Comm	Inop	Mil	Comm	Inop	
1	0	0	0	0	0	0	1	1	l(1)	
2	0	0	0	1	0	0				
3	0	0	0	0	0	0				
Total	0	0	0	1	0	0	1	1	1	

^{1.} Unit #166 failed due to metal migration on lead frame external to body of device.

9. Sequence Test No. 2

Sequence Test No. 2 consisted of 50 cycles of thermal shock at -65°C to +150°C plus 160 hours of 125°C operating life. Three complete cycles of this sequence test were run on types CA741, CD4012 and 54S20. The data for these tests is summarized in Table IV-17.

- a. <u>CA741</u> The test sample for the type CA741 consisted of four plastic and two ceramic devices. There were no failures in either group.
- b. <u>CD4012</u> The test sample for the type CD4012 consisted of five plastic and one ceramic device. There were no failures in either group.
- c. 54820 The test sample for the type 54820 consisted of five plastic and one ceramic device. There were no failures in either group.

10. Sequence Test No. 3

Sequence Test No. 3 consisted of fifteen cycles of thermal shock at -65°C to +150°C plus ten cycles of temperature cycling at -65°C to +150°C plus 10 days of moisture-resistance tests. Three complete cycles of this sequence test were run on types CA741, CD4012, and 54S20. Test data is summarized in Table IV-18.

- a. <u>CA741</u> The test sample for the type CA741 consisted of five plastic and one ceramic device. The plastic cell experienced one parametric failure at the second cycle and one at the third.
- b. <u>CD4012</u> The test sample for the type CD4012 consisted of three plastic and two ceramic devices. The plastic cell experienced one parametric failure to commercial limits at the third cycle. The device was baked at 150°C for 16 hours. The unit recovered to commercial limits, but still failed military limits. The ceramic cell experienced two parametric failures to military limits at the third cycle.

Table IV-17 - Thermal Shock +125°C Operating-Life Test Sequence (#2) Summary

PLASTIC

	CA741			CD40	12		54\$20					
			N=5			N=5			N=5			
<u>Cy</u>	cles	Mil	Comm	Inop	M11	Comm	Inop	Mi1	Comm	Inop		
	1	0	0	0	0	0	0	0	0	0		
	2	0	0	0	0	0	0	0	0	0		
	3	0	0	0	0	0	0	0	0	0		
Total		0	0	0	0	0	0	0	0	0		

	CA741				CD40	12		54\$20			
			N=2			N=1			N=1		
<u>C</u>	ycles	Mil	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop	
	1	0	0	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	
Total		0	0	0	0	0	0	0	0	0	

Table IV-18 - Thermal-Shock Temperature-Cycle Moisture-Resistance Test Sequence (#3) Summary

PLASTIC

		CA741 N=5			CD4012 N=3			54S20 N=5			
<u>(</u>	Cycles	M11	Comm	Inop	Mil	Comm	Inop	Mil	Comm	Inop	
	1	0	0	0	0	0	0	0	0	0	
	2	1	1(1)	0	_	_	-	0	0	0	
	3	1	l(1)	0	1	1(2)	1	0	0	0	
Total		2	2	0	1	1	0	0	0	0	

	CA741 N=3				CD40			54S20 N=2			
	Cycles	Mil	Сот	Inop	M11	Comm	Inop	Mil	Comm	Inop	
	1	0	0	0	0	0	0	0	0	0	
	2	0	0	0	_	-	-	0	0	0	
	3	0	0	0	2	0	0	0	0	0	
Total	Ĺ	0	0	0	2	0	0	0	0	0	

- 1. Number 199 failed after 2 cycles for -PSRR and IIB. Device was kept on test. Number 198 failed for multiple parameters after 3 cycles. Number 199 became worse after 3 cycles. Both units were baked at 150°C for 4 hrs. Both recovered.
- 2. Number 348 failed $I_{\rm SS}$, IIH2 after 3 cycles. Unit baked at 150°C for 16 hrs. Recovered to commercial limit, but still failed MIL limit.

- c. 54820 The test sample for the type 54820 consisted of five plastic and two ceramic devices. There were no failures in either cell.
- D. Computerized Data Analysis

General

The data collected in Phase III of the program is shown in three different formats in Tables IV-19 and Figures IV-12 and IV-13. The alphanumeric code associated with each set of readings, for example AA50A01, may be read as follows:

- 1. The first letter represents the test-duration measurement units:
 - A = hours
 - B = cycles for single tests
 - C = cycles for sequence tests
- 2. The second letter represents the down time:
 - A = 0 hours
- E = 168 hours
- I = 2000 hours

- B = 24 hours
- F = 200 hours
- J = 2500 hours

- C = 248 hours
- G = 500 hours
- K = 5000 hours

- D = 96 hours
- H = 1000 hours
- 3. The third position represents the contract phase:
 - 5 = Phase III
- 4. The fourth-position digit represents the device type:
 - 0 = CA741
- 3 = 5470
- 1 = CD4012
- 4 = 5472
- 2 = 5420
- 5 = 54820

- 5. The fifth letter represents the test being run:
 - A = 125°C Operating-Life Test
 - H = 85°C/85% R.H. Bias/Humidity Test
 - I = Autoclave
 - J = Salt Atmosphere
 - K = Thermal Shock
 - L = Temperature Cycle
 - M = Sequence Test No. 1
 - N = Sequence Test No. 2
 - P = Sequence Test No. 3
- 6. The sixth and seventh digits represent the type of package:
 - 01 = plastic
 - 02 = ceramic

The example given, AA50A01 is, then, the data code for the zero hour, Phase III, CA741, 125°C operating-life test. The units are molded in a plastic package.

2. Delta Analysis

Table IV-19 shows the delta analysis on V_{IO} readings of the 125°C operating life test between 0 and 168 hours. The data for all 150 units in the test are shown. This type of information is available for all of the tests and between any two sets of readings on all of the integrated-circuit types.

3. Histogram

An example of a histogram depiction of data is shown in Figure IV-12. The figure presents the zero-hour $V_{\rm IO}$ readings on the CA741, 125°C operating-life test. A similar histogram can be generated for any parameter, for any test on each type.

Table IV-19 - Data Analysis

PAGE

```
DATE PRINTED : 06/12/81
                                                         TIME PRINTED : 5.30.
DELTA AT 168HRS
TYPE =CA741
LOT =AA50A01 OR AE50A01
CHIP =NOT 800 IF DEGC IS 25
TEST =FROM 1 TO 28
DELTA OPTION
ROW=CHIP
  COL=LOT
      =TVAL AND RANGE AND UNITS AND REJ
          =CA741
TYPE
TEST
CHIP
           AA50A01
                             AE50A01
                                               AE50A01
                                                -AA50A01
            6.000E-02MV
                               4.000E-02MV
                                                -2.000E-02MV
           -1.600E-01MV
8.600E-01MV
                                                2.400E-01MV
5.000E-02MV
1.000E-02MV
                               8.000E-02MV
9.100E-01MV
                             -1.990E+00MV
           -2.000E+00MV
                                                 1.100E-01MV
9.999E-03MV
             4.600E-01MV
                               5.700E-01MV
            1.120E+00MV
                               1.130E+00MV
            8.200E-01MV
                                               3.000E-02MV
-1.200E-01MV
                               8.500E-01MV
            1.590E+00MV
                               1.470E+00MV
             4.300E-01MV
                               5.700E-01MV
                                                 1.400E-01MV
                                                 1.400E-01MV
       10
            1.520E+00MV
                               1.660E+00MV
                                                 6.000E-02MV
        11
            1.290E+00MV
                               1.350E+00MV
                                                1.200E-01MV
1.300E-01MV
1.500E-01MV
2.400E-01MV
             2.200E+00MV
                               2.320E+00MV
            2.200E-01MV
                               3.500E-01MV
           -1.500E-01MV
                                         MV
                               0.0
                               1.600E+00MV
        15
            1.360E+00MV
            1.450E+00MV
                                               -2.000E-02MV
1.500E-01MV
                             1.430E+00MV
-9.900E-01MV
       16
        17
           -1.140E+00MV
            1.850E+00MV
                               2.180E+00MV
                                                 3.300E-01MV
        18
             1.220E+00MV
                               1.340E+00MV
                                                 1.200E-01MV
        20
             1.150E+00MV
                               1.140E+00MV
                                               -1.000E-02MV
                             2.200E+00MV
-1.500E-01MV
             1.980E+00MV
                                                2.200E-01MV
5.000E-02MV
        21
           -1.000E-01MV
            1.420E+00MV
                               1.620E+00MV
        23
                                                 2.000E-01MV
             3.800E-01MV
                               5.200E-01MV
                                                 1.400E-01MV
             1.750E+00MV
                               1.770E+00MV
                                                 2.000E-02MV
            7.100E-01MV
2.200E-01MV
                               7.200E-01MV
3.300E-01MV
                                                 1.000E-02MV
1.100E-01MV
            5.100E-01MV
9.300E-01MV
        28
                               7.000E-01MV
                                                 1.900E-01MV
                               9.300E-01MV
                                                 0.0
                                                            MV
           -1.190E+00MV
                             -1.170E+00MV
                                                 2.000E-02MV
       30
                                                 5.000E-02MV
2.000E-01MV
       31 -2.000E-02MV
32 -6.500E-01MV
                               3.000E-02MV
                             -4.500E-01MV
                                                6.000E-02MV
-2.000E-02MV
            1.300E-01MV
                               1.900E-01MV
             1.070E+00MV
                               1.050E+00MV
                                                1.000E-01MV
1.900E-01MV
                               1.770E+00MV
            1.670E+00MV
           -3.900E-01MV
                              -2.000E-01MV
        36
            2.030E+00MV
       37
                               2.110E+00MV
                                                 8.000E-02MV
        38
             1.150E+00MV
                               1.180E+00MV
                                                 3.000E-02MV
                                                -8.000E-02MV
        39
           -7.000E-02MV
                             -1.500E-01MV
        40
             1.540E+00MV
                               1.750E+00MV
                                                 2.100E-01MV
                              -1.530E+00MV
           -1.620E+00MV
                                                 9.000E-02MV
           -9.700E-01MV
                                                 1.400E-01MV
                             -8.300E-01MV
```

Table IV-19 - Data Analysis (continued)

```
PAGE
         2
       43 -7.700E-01MV
                           5.400E-01MV
                                           1.310E+08MV
      44 -1.250E+00MV
                          -1.280E+00MV
                                          -3.000E-02MV
         -2.000E-02MV
                          -2.800E-01MV
                                          -2.600E-01MV
           4.400E-01MV
                           5.200E-01MV
                                           8.000E-02MV
           1.790E+00MV
                           1.900E+00MV
                                           1.100E-01MV
           2.190E+00MV
                           2.620E+00MV
                                           4.300E-01MV
           2.800E-01MV
8.900E-01MV
                           6.300E-01MV
                                           3.500E-01MV
                           1.280E+00MV
      50
                                           3.900E-01MV
           1.390E+00MV
                           1.470E+00MV
                                           8.000E-02MV
      52
           9.400E-01MV
                           9.900E-01MV
                                           5.000E-02MV
                           8.300E-01MV
           7.600E-01MV
                                           7.000E-02MV
           9.600E-01MV
                           1.130E+00MV
                                           1.700E-01MV
      55
           3.900E-01MV
                                          -1.000E-02MV
                           3.800E-01MV
                                          -2.000E-02MV
                           1.410E+00MV
5.700E-01MV
      56
           1.430E+00MV
           5.500E-01MV
      57
                                           2.000E-02MV
           1.220E+00MV
                            .260E+00MV
                                           4.000E-02MV
       59
          -6.600E-01MV
                          -5.900E-01MV
                                           7.000E-02MV
                           1.750E+00MV
      60
           1.670E+00MV
                                           8.000E-02MV
           1.830E+00MV
                           2.590E+00MV
                                           7.600E-01MV
      61
                                           1.800E-01MV
           7.500E-01MV
                           9.300E-01MV
      62
                           1.610E+00MV
                                           4.000E-02MV
      63
           1.570E+00MV
           3.100E-01MV
                           4.300E-01MV
      64
                                           1.200E-01MV
           8.70GE-01MV
9.800E-01MV
                           1.210E+00MV
      65
                                           3.400E-01MV
      66
                           1.110E+00MV
                                           1.300E-01MV
      67
           7.800E-01MV
                           9.500E-01MV
                                           1.700E-01MV
           1.990E+00MV
                           2.090E+00MV
      68
                                           1.000E-01MV
           1.380E+00MV
                           1.500E+00MV
                                           1.200E-01MV
           1.290E+00MV
                           1.400E+00MV
      70
                                           1.100E-01MV
          -1.300E-01MV
                          -6.000E-02MV
      71
                                           7.000E-02MV
          4.000E-01MV
-1.150E+00MV
      72
                           4.400E-01MV
                                           4.000E-02MV
      73
                          -1.130E+00MV
                                           2.000E-02MV
      74
           8.000E-01MV
                           8.300E-01MV
                                           3.000E-02MV
           2.800E-01MV
9.000E-01MV
      75
                           9.900E-01MV
                                           7.100E-01MV
                                           2.000E-01MV
                           1.100E+00MV
           7.300E-01MV
2.200E-01MV
                                           6.200E-01MV
      77
                           1.350E+00MV
      78
                           2.400E-01MV
                                           2.000E-02MV
           1.190E+00MV
      79
                           1.240E+00MV
                                           5.000E-02MV
      80
           1.210E+00MV
                                           6.700E-01MV
                           1.880E+00MV
           1.960E+00MV
                           2.070E+00MV
                                           1.100E-01MV
      81
      82
           7.600E-01MV
                           8.700E-01MV
                                           1.100E-01MV
           6.300E-01MV
      83
                           5.900E-01MV
                                          -4.000E-02MV
      84
           1.160E+00MV
                           1.290E+00MV
                                           1.300E-01MV
                                           4.900E-01MV
      85
           9.800E-01MV
                           1.470E+00MV
           7.300E-01MV
2.100E-01MV
      86
                           8.600E-01MV
3.200E-01MV
                                           1.300E-01MV
      87
                                           1.100E-01MV
                                           6.000E-02MV
          -1.150E+00MV
                          -1.090E+00MV
      88
                                           3.890E+00MVF
      89
           6.000E-01MV
                            .490E+00MVF
           8.700E-01MV
                           9.900E-01MV
       90
                                           1.200E-01MV
       91
           9.400E-01MV
                           1.000E+00MV
                                           6.000E-02MV
           4.200E-01MV
                           4.000E-01MV
                                          -2.000E-02MV
                                           3.000E-02MV
                           9.100E-01MV
1.690E+00MV
           8.800E-01MV
       93
           1.590E+00MV
                                           1.000E-01MV
       95
           9.900E-01MV
                             .030E+00MV
                                           4.000E-02MV
           2.500E-01MV
       96
                             .300E-01MV
                                           3.800E-01MV
                           8.300E-01MV
       97
           7.600E-01MV
                                           7.000E-02MV
       98
           1.210E+00MV
                           1.310E+00MV
                                           1.000E-01MV
           7.600E-01MV
                           8.600E-01MV
                                           1.000E-01MV
           5.100E-01MV
                           5.900E-01MV
      100
                                           8.000E-02MV
```

Table IV-19 - Data Analysis (continued)

```
PAGE
            9.000E-01MV
3.300E-01MV
                              9.100E-01MV
6.500E-01MV
      101
                                               1.000E-02MV
      102
                                               3.200E-01MV
             1.490E+00MV
                              1.610E+00MV
                                               1.200E-01MV
      103
      104
            1.150E+00MV
                              1.210E+00MV
                                               6.000E-02MV
      105
            0.0
                       MV
                              3.000E-02MV
                                               3.000E-02MV
                             -8.900E-01MV
2.700E-01MV
      106
           -1.110E+00MV
                                               2.200E-01MV
1.300E-01MV
      107
            1.400E-01MV
      108
            1.290E+00MV
                              1.450E+00MV
                                               1.600E-01MV
             4.200E-01MV
      109
                                               7.000E-02MV
                              4.900E-01MV
            1.010E+00MV
                              1.150E+00MV
                                               1.400E-01MV
      110
            6.300E-01MV
8.300E-01MV
      111
                              7.900E-01MV
                                               1.600E-01MV
                              9.700E-01MV
                                               1.400E-01MV
      112
      113
             1.630E+00MV
                              1.800E+00MV
                                               1.700E-01MV
             1.900E+00MV
                              2.050E+00MV
                                               1.500E-01MV
       114
                                               3.000E-01MV
1.100E-01MV
      115
             1.100E+00MV
                              1.400E+00MV
      116
            1.990E+00MV
                              2.100E+00MV
           -6.500E-01MV
                            -5.200E-01MV
1.200E-01MV
                                               1.300E-01MV
      117
            2.000E-02MV
      118
                                               1.000E-01MV
             1.160E+00MV
      119
                              1.270E+00MV
                                               1.100E-01MV
            7.000E-02MV
4.900E-01MV
                             2.000E-01MV
-4.700E-01MV
       120
                                               1.300E-01MV
2.000E-02MV
       121
      122
123
                             1.080E+00MV
             9.900E-01MV
                                               9.000E-02MV
             1.030E+00MV
                              1.190E+00MV
                                               1.600E-01MV
      124
             1.720E+00MV
                              1.840E+00MV
                                               1.200E-01MV
      125
             1.110E+00MV
                              1.340E+00MV
                                               2.300E-01MV
                                               6.000E-02MV
      126
            2.200E-01MV
                              2.800E-01MV
      127
             1.670E+00MV
                             -1.600E+00MV
                                               7.000E-02MV
      128
129
130
                                               1.600E-01MV
            1.790E+00MV
                              1.950E+00MV
            2.700E-01MV
6.300E-01MV
                             4.400E-01MV
7.000E-01MV
                                               1.700E-01MV
                                               7.000E-02MV
4.000E-02MV
             3.100E-01MV
                              3.500E-01MV
      131
       132
             1.050E+00MV
                              1.220E+00MV
                                               1.700E-01MV
       133
             7.000E-01MV
                              8.300E-01MV
                                               1.300E-01MV
      134
            7.100E-01MV
2.500E-01MV
                              9.100E-01MV
4.400E-01MV
                                               2.000E-01MV
1.900E-01MV
      135
             1.440E+00MV
                              1.580E+00MV
                                               1.400E-01MV
      136
      137
             7.700E-01MV
                              8.700E-01MV
                                               1.000E-01MV
                                               2.000E-01MV
       138
             4.100E-01MV
                              6.100E-01MV
             5.900E-01MV
                                               6.000E-02MV
1.200E-01MV
       139
                              6.500E-01MV
       140
             2.190E+00MV
                              2.310E+00MV
       141
           -2.800E-01MV
                             -2.100E-01MV
                                               7.000E-02MV
           -1.500E-01MV
                             -7.000E-02MV
                                               8.000E-02MV
       142
       143
            2.000E-02MV
                              1.500E-01MV
                                               1.300E-01MV
1.100E-01MV
             1.820E+00MV
       144
                              1.930E+00MV
      145
             4.600E-01MV
                              5.700E-01MV
                                               1.100E-01MV
       146
             1.190E+00MV
                              1.340E+00MV
                                               1.500E-01MV
       147
           -2.900E-01MV
                             -1.900E-01MV
                                               1.000E-01MV
       148
             1.470E+00MV
                              1.600E+00MV
                                               1.300E-01MV
             7.600E-01MV
                                               6.000E-02MV
       149
                              8.200E-01MV
      150
             2.600E-01MV
                                               1.200E-01MV
                              3.800E-01MV
COUNT
             1.500E+02
                              1.500E+02
                                               1.500E+02
                              8.349E-01MV
9.230E-01MV
MEAN
             6.778E-01MV
                                               1.571E-01MV
                                               3.495E-01MV
1.221E-01
SIGMA
             8.484E-01MV
             7.198E-01
"VARIANCE
                              8.519E-01
             1.252E+02
COEF VAR
                                               2.224E+02
                              1.105E+02
 STD SKEW
           -6.722E-01
                             -1.936E-01
                                               8.439E+00
MIN VAL
            -2.000E+00MV
                             -1.990E+00MV
                                              -2.600E-01MV
MAX VAL
                                               3.890E+00MV
             2.200E+00MV
                              4.490E+00MV
MEAN+S
             1.526E+00MV
                              1.758E+00MV
                                               5.066E-01MV
            -1.706E-01MV
                                              -1.924E-01MV
MEAN-S
                             -8.806E-02MV
 SKEW PT
             2.222E-01MV
                                               1.483E+00MV
                              6.733E-01MV
```

```
SUMMARY DATA HISTOGRAM:

DATE PRINTED: 07/09/81

VIO(T1) HISTOGRAM

FOR TYPE = CA741

FOR LOT = AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01

FOR TEST =1 IF DEGC IS 25 IF SUMID IS VIOTREND

TYPE = CA741
                                                                                       TIME PRINTED : 3.37.58
                                              = AA50A01
                              LOT
                              TEST
                                                           1 PARAMETER: VIO
                                                                              .5....×M.....S..×.
                          -3.00E-03 -1.80E-03 -6.00E-04 6.00E-04 1.80E-03 3.00E-03
SAMPLE SIZE: 150 PLOTTED: 150 BELOW: 0 ABOVE: 0 COUNT PER +: 1 CELL WIDTH: 1.20E-04 MIN VAL:-2.000E-03 MAX VAL: 2.200E-03 UNITS: V MEAN: 6.778E-04 MEDIAN: 7.600E-04 17% POINT: -2.000E-05 84% POINT: 1.490E-03
```

Fig. IV-12 - Summary data histogram.

4. Trend Analysis

A trend analysis for V_{10} on the CA741, 125°C operating-life test is shown in Figure IV-13. The down periods represented are 0, 168, 1,000, 2,000, and 5,000 hours. The median values are represented by an X and the length of the vertical lines is the 17% to 84% range. This type of chart shows the parametric shifts over the course of the tests and can be generated for any parameter on each type on each test.

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01 Y=MED OR 17% OR 84%
                                                         TIME PRINTED : 3.37.18
                              = CA741
= 1 PARAMETER: VIO
TREND PLOT FOR: TYPE
                    TEST
LEGEND: /MED = X/17
CELL WIDTH: 1.50E-04
3.00E-03 *
                                   =1/84%
                     =X/17%
                               MULTIPLE: >
                                                                                   * 3.00E-03
                                                                                   × 2.25E-03
      2.25E-03 ×
                                                                                   × 1.50E-03
      1.50E-03 ×
      7.50E-04 ×
                                                                                   × 7.50E-04
                                                                                   × 1.40E-09
      1.40E-09 ×
                                                                                   *-7.50E-04
     -7.50E-04 *
                                                                                   *-1.50E-03
     -1.50E-03 ×
                                                                                   *-2.25E-03
     -2.25E-03 ×
                                                                                   *-3.00E-03
     -3.00E-03 ×
                    LOT
```

Fig. IV-13 - Trend analysis.

DATE PRINTED : (TIME	PRINTED	: 3.37.18
TYPE =CA741 IF	DEGC IS 25 IF SUM R AE50A01 OR AH50	MID IS VIOTR DA01 OR AI50	END A01 OR	AK50A01	
TREND PLOT FOR:	TYPE = CA741 TEST = :	2			
LEGEND: /MED CELL WIDTH: 1.0 2.70E-03 *	=X/17% = [/8 00E-04 MULTIP	84% = 1/			* 2.70E-03
•					•
2.20E-03 *					* 2.20E-03
:					•
1.70E-03 *		ı			: * 1.70E-03
:				-	
1.20E-03 ×					× 1.20E-03
•		× į			
7.00E-04 *	×			× !	X × 7.00E-04
:					
2.00E-04 *					* 2.00E-04
•	1			1	
-3.00E-04 ×					×-3.00E-04
•					:
-8.00E-04 *					×-8.00E-04
•					•
-1.30E-03 *		.			*-1.30E-03
LOT	AA50A01 AE50A0	i ÄHSÖÄÖİ .	ÀÌSOÁO	i [*] aksoao	1

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01 Y=MED OR 17% OR 84%
                                                         TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE
                   TEST
=X/17%
LEGEND: /MED =X/17
CELL WIDTH: 1.00E-04
                                   =1/84%
                                                 =1/
                               MULTIPLE: >
      2.80E-03 ×
                                                                                   × 2.80E-03
      2.30E-03 ×
                                                                                   * 2.30E-03
      1.80E-03 ×
                                                                                   × 1.80E-03
      1.30E-03 ×
                                                                                   * 1.30E-03
      8.00E-04 ×
                                                                                   * 8.00E-04
      3.00E-04 ×
                                                                                   × 3.00E-04
     -2.00E-04 ×
                                                                                   ×-2.00E-04
     -7.00E-04 ×
                                                                                   ×-7.00E-04
     -1.20E-03 ×
                                                                                   *-1.20E-03
                    LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01 Y=MED OR 17% OR 84%
                                                                 TIME PRINTED : 3.37.18
                                  = CA741
TREND PLOT FOR: TYPE
                      TYPE = CA741
TEST = 4
=X/17% = 1/84%
LEGEND: /MED =X/17:
CELL WIDTH: 1.00E-04
2.60E-03 *
                                                        = | /
                                   MULTIPLE: >
                                                                                              * 2.60E-03
       2.10E-03 ×
                                                                                              * 2.10E-03
       1.60E-03 ×
                                                                                              * 1.60E-03
       1.10E-03 ×
                                                                                              * 1.10E-03
       6.00E-04 ×
                                                                                                6.00E-04
       1.00E-04 ×
                                                                                              × 1.00E-04
      -4.00E-04 ×
                                                                                              *-4.00E-04
      -9.00E-04 ×
                                                                                              *-9.00E-04
     -1.40E-03 ×
                                                                                              *-1.40E-03
                      AA50A01 AE50A01 AH50A01 AI50A01 AK50A01
        LOT
```

Fig. IV-13 - Trend analysis (continued).

TYPE = CA741 IF DEGC IS 25 IF SUMID IS VIOTREND LOT = A50001 OR AE50001 OR AH50001 OR AK50001 Y=MED OR 17% OR 84% TREND PLOT FOR: TYPE = CA741	DATE PRINTED : VIO(T1) VS TIME			TIME	PRINTED	3.37.1	8
TEST = 6 PARAMETER: IIO = 1/84 = 1/8	TYPE =CA741 IF LOT =AA50A01 0	DEGC IS 25 IF SUDER AESOAGE OR AH!	JMID IS VI 50A01 OR A	OTREND 150A01 OR	AK50A01		
LEGEND: VMED = X/17% = /84% = / CELL WIDTH: 1.50E-09 MULTIPLE: >	TREND PLOT FOR:			TED: TTA			
3.00E-08 × × 3.00E-08 2.25E-08 × × 2.25E-08 1.50E-08 × × 1.50E-08 7.50E-09 × × 7.50E-09 1.07E-14 × × × × × × × × × × × × × × × × × × ×		=X/17% = I	/84% =				
1.50E-08 ×		.50E-09 MULIII	LE: >			×	3.00E-08
1.50E-08 ×	•					•	
1.50E-08 ×	:					•	
7.50E-09 *	2.25E-08 ×	•				*	2.25E-08
7.50E-09 *	•	•				•	
7.50E-09 *							1 50F-08
1.07E-14 * X X X X X X 1.07E-14 -7.50E-09 *	1.506-08 *					•	1.500 00
1.07E-14 * X X X X X X 1.07E-14 -7.50E-09 *	•	•				•	
-7.50E-09 × ×-7.50E-09 -1.50E-08 × ×-1.50E-08 -2.25E-08 × ×-2.25E-08	7.50E-09 ×	(×	7.50E-09
-7.50E-09 × ×-7.50E-09 -1.50E-08 × ×-1.50E-08 -2.25E-08 × ×-2.25E-08	:	•				•	
-7.50E-09 × ×-7.50E-09 -1.50E-08 × ×-1.50E-08 -2.25E-08 × ×-2.25E-08			ì	ı	1	1 :	
-7.50E-09 × ×-7.50E-09 -1.50E-08 × ×-1.50E-08 -2.25E-08 × ×-2.25E-08	1.07E-14	× X	į X	X	X		1.07E-14
-1.50E-08 × ×-1.50E-08 -2.25E-08 × ×-2.25E-08	•	. i	Î	Ĩ		1	
-1.50E-08 × ×-1.50E-08 -2.25E-08 × ×-2.25E-08	-7 E0E-00 \	• •	'		•		-7 50F-09
2.25E-08 × ×-2.25E-08	-7.506-09 9	•				•	7.502 07
2.25E-08 × ×-2.25E-08	•	•				•	
	-1.50E-08	*				×	-1.50E-08
		•				•	
		•				•	
	2.25E-08 3	Ř			•	×	-2.25E-08
		•				•	
	-3.00E-08	• • •					-3.00E-08
LOT AASOADI AESOADI AHSOADI AISOADI AKSOADI		×	¥	. ¥	.×	. x	2.002 30

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                           TIME PRINTED : 3.37.18
                              = CA741
= 8
=1/84%
TREND PLOT FOR: TYPE
LEGEND: /MED = X/17% CELL WIDTH: 1.00E-09 1.90E-08 *
                                                   =1/
                                MULTIPLE: >
                                                                                      * 1.90E-08
                                                                                      * 1.40E-08
      1.40E-08 ×
                                                                                      × 9.00E-09
       9.00E-09 ×
                                                                                      * 4.00E-09
       4.00E-09 ×
                                                                                      ×-1.00E-09
     -1.00E-09 ×
                                          X
                                                                             X
                                                                                      ×-6.00E-09
     -6.00E-09 ×
                                                                                      X-1.10E-08
     -1.10E-08 ×
      -1.60E-08 ×
                                                                                      *-1.60E-08
                                                                                      ×-2.10E-08
      -2.10E-08 ×
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/ VIO(T1) VS TIME	18/81	TIME PRIN	TED : 3.37.18
TYPE =CA741 IF DEG		S VIOTREND OR AI50A01 OR AK50	A01
TREND PLOT FOR: TY			
	ST = 10 X/17% = /84% -10 MULTIPLE: >	=1/	× 2.60E-09
•			•
1.60E-09 *			: * 1.60E-09
•		1 1	1 :
6.00E-10 ×			× 6.00E-10
-4.00E-10 *			×-4.00E-10
:			:
-1.40E-09 *			*-1.40E-09
:	, i	×	:
-2.40E-09 ×		×	X ×-2.40E-09
•	×		
-3.40E-09 ×			*-3.40E-09
:			
4.48E-89 ×	1	1	*-4.40E-09
-5.40E-09 ×		j	×-5.40E-09
• • •	×		¥

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 VIO(T1) VS TIME	TIME	PRINTED : 3.37.18
TYPE =CA741 IF DEGC IS 25	5 IF SUMID IS VIOTREND OR AH50A01 OR AI50A01 OR	AK50A01
	= CA741	
TEST : LEGEND: /MED = X/17% CELL WIDTH: 2.00E-10 3.00E-09 *	= 12 = /84% = / MULTIPLE: >	* 3.00E-09
•		. 3.002 07
: 1		:
2.00E-09 ¥		* 2.00E-09
	1	:
1.00E-09 ×		* 1.00E-09
:] ;
0.0 ×		* a.a
:		:
-1.00E-09 * X		×-1.00E-09
:	×	× :
-2.00E-09 ×	X	X *-2.00E-09
:		1 :
-3.00E-09 ×		×-3.00E-09
: 1		
-4 005-00 ×		
4.00E-09 ×		×-4.00E-09
•	1	•
-5.00E-09 ×	.	*-5.00E-09
LOT AASOAOI	AE50A01 AH50A01 A150A01	AK50A01

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : VIO(T1) VS TIM	E	TE CHAIR			PRINTED	: 3.37.	18
TYPE =CA741 IF LOT =AA50A01 (Y=MED OR 1	OR AE50A01	OR AHSOAD	L OR AISOAO	OR	AK50A01	-	
TREND PLOT FOR		CA741	PARAMETER:	+IIB			
LEGEND: /MED CELL WIDTH: 4	=X/17% .95E-09	=1/84% MULTIPLE:	= 17				
9.90E-08	* • •						× 9.90E-08
7 405 00	• •						•
7.42E-08	* •						× 7.42E-08
	• •						•
4.95E-08	.						* 4.95E-08 ·
	•						•
2.48E~08	¥ •						* 2.48E-08
	•						•
5.68E~14	•						× 5.68E-14
	: 1				1	1	•
-2.47E-08	Å J	į ×	į ×		i ×	į ×	X-2.47E-08
	: X		ł		ł	1	:
-4.95E-08	•						×-4.95E-08
	•						•
-7.42E~08	K						×-7.42E-08
	•						•
-9.90E-08	H 	×	. 		*	. *	×-9.90E-08
LOT	AA50A01	AE50A01 A	H50A01 AIS	50A01	AK50A0	1	

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : VIO(T1) VS TIM				TIME	PRINTED :	3.37.18
TYPE =CA741 IF	DEGC IS 2 Or AE50A01	S IF SUMI OR AH50A	D IS VIOTR 01 OR A150	END A01 OR	AK50A01	
TREND PLOT FOR		= CA741				
LEGEND: /MED	TEST =X/17%	= 784				
CELL WIDTH: 1 -2.70E-08		MULTIPLE	. ,			*-2.70E-08
	: 1	1			1	1 :
			Ī		1	:
-3.20E-08	*	ļ	}		ł	*-3.20E-08
	:		İ			:
-3.70E-08	*	İ			•	*-3.70E-08
		İ	İ			
		į	İ		İ	
-4.20E-08	×	İ				¥-4.20E-08
	:					
-4.70E-08	×	1	1		ł	×-4.70E-08
	:	1	1		}	:
-5.20E-08	×	İ	Ì	•	j X	*-5.20E-08
	:	X I	Ĩ	·	Ĩ	× ·
		,	ļ		İ	
-5.70E-08			į			×-5.70E-08
			İ			
			Ì			
-6.20E-08	*		1		1	×-6.20E-08
	:					•
-6.70E-08	. *					*-6.70E-08
LOT	AA50A01		AH50A01	ATSOAGI	* AK50A01	

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                        TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE
                             = CA741
                            = 18
% =|/84%
                   LEGEND: /MED = X/17:
CELL WIDTH: 1.00E-09
-1.60E-08 *
                                                =1/
                             MULTIPLE: >
                                                                                *-1.60E-08
     -2.10E-08 ×
                                                                                 *-2.10E-08
    -2.60E-08 ×
                                                                                 X-2.60E-08
     -3.10E-08 ×
                                                                                 *-3.10E-08
     -3.60E-08 ×
                                                                                 *-3.60E-08
     -4.10E-08 ×
                                                                                 ×-4.10E-08
     -4.60E-08 ×
                                                                                 ×-4.60E-08
     -5.10E-08 ×
                                                                                 *-5.10E-08
     -5.60E-08 ×
                                                                                 K-5.60E-08
                   LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01 Y=MED OR 17% OR 84%
                                                           TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE
                              = CA741
= 20
= 1/84%
                  TEST = X/17%
LEGEND: /MED =X/17
CELL WIDTH: 1.00E-09
-1.40E-08 *
                                                   = 1/
                                MULTIPLE: >
                                                                                     *-1.40E-08
     -1.90E-08 >
                                                                                     *-1.90E-08
     -2.40E-08 ×
                                                                                     X-2.40E-08
     -2.90E-08 ×
                                                                                     ×-2.90E-08
     -3.40E-08 ×
                                                                                     ×-3.40E-08
     -3.90E-08 ×
                                                                                     *-3.90E-08
     -4.40E-08 ×
                                                                                     ×-4.40E-08
     -4.90E-08 ×
                                                                                     *-4.90E-08
     -5.40E-08 ×
                                                                                     ×-5.40E-08
                     LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AK50A01

Y=MED OR 17% OR 84%
                                                            TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE
                                = CA741
                    TEST = X/17%
                               = 22 PARAMETER: -IIB
= |/84% = |/
MULTIPLE: >
LEGEND: /MED =X/17
CELL WIDTH: 4.95E-09
9.90E-08 *
                                                                                       × 9.90E-08
      7.42E-08 ×
                                                                                       * 7.42E-08
      4.95E-08 ×
                                                                                       × 4.95E-08
      2.48E-08 ×
                                                                                       * 2.48E-08
      5.68E-14 ×
                                                                                         5.68E-14
     -2.47E-08 ×
                                                                                       ×-2.47E-08
     -4.95E-08 ×
                                                                                       ×-4.95E-08
     -7.42E-08 ×
                                                                                       ×-7.42E-08
     -9.90E-08 ×
                    LOT
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : VIO(T1) VS TIM			TIM	E PRINTED	: 3.37.18
TYPE =CA741 IF	DEGC IS 2 DR AE50A01	25 IF SUMID 1 L OR AH50A01	S VIOTREND OR AI50A01 O	R AK50A01	
TREND PLOT FOR	: TYPE Test	= CA741 = 24			
LEGEND: /MED CELL WIDTH: 2 8.60E-08	=X/17% .00E-09	= 784%	= /		× 8.60E-08
	•				•
7.60E-08	- X				* 7.60E-08
	•				•
6.60E-08	*				. 6.60E-08
5.60E-08	*				. 5.60E-08
4.60E-08	*	Ì	× 	*	X : × 4.60E-08 :
3.60E-08	*				* 3.60E-08 :
2.60E-08	• * •				* 2.60E-08
_ 1.60E-08	*				* 1.60E-08 :
6.00E-09	• • *				: * 6.00E-09
LOT	AA50A01	*	 H50A01 AI50A		* D

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                          TIME PRINTED : 3.3/.18
TREND PLOT FOR: TYPE
                               = CA741
                    TEST
=X/17%
                                    26
=|/84%
LEGEND: /MED = X/17
CELL WIDTH: 1.00E-09
5.40E-08 ×
                                                  =1/
                                MULTIPLE: >
                                                                                    * 5.40E-08
      4.90E-08 ×
                                                                                    × 4.90E-08
      4.40E-08 ×
                                                                                      4.40E-08
      3.90E-08 ×
                                                                                    × 3.90E-08
      3.40E-08 ×
                                                                                    * 3.40E-08
      2.90E-08 ×
                                                                                    × 2.90E-08
      2.40E-08 ×
                                                                                    × 2.40E-08
      1.90E-08 ×
                                                                                    × 1.90E-08
                                                                                    × 1.40E-08
      1.40E-08 ×
                    LOT
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : VIO(T1) VS TIM	Ε,			IME PR	INTED : 3	.37.18
TYPE =CA741 IF	DEGC IS 2 OR AE50A01	25 IF SUMIT L OR AH50A0) IS VIOTREND 11 OR AI50A01	OR AK	50A01	
TREND PLOT FOR		= CA741 = 28				
LEGEND: /MED CELL WIDTH: 1, 5.30E-08	TEST =X/17% .00E-09	=1784%				× 5.30E-08
	•					:
4.80E-08	• •					* 4.80E-08
4.30E-08				1	1	* 4.30E-08
			j			:
3.80E-08	, , , , , , , , , , , , , , , , , , ,					* 3.80E-08
3.30E-08 >	•	×	×	×	×	: : : * 3.30E-08
•						•
2.80E-08						* 2.80E-08
2.30E-08						: : * 2.30E-08
•						•
_ 1.80E-08 \$						* 1.80E-08
1.30E-08	·					
1.30E-08 P	' 'AA50A01		AH50A01 AI5	ÄÖİ /		× 1.30E-08

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) V5 TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                              TIME PRINTED : 3.37.18
                                = CA741
= 30 PARAMETER: +PSRR
=|/84% =|/
MULTIPLE: >
TREND PLOT FOR: TYPE
                     TEST = = X/17%
LEGEND: /MED =X/17
CELL WIDTH: 1.00E-08
2.00E-07 *
                                                                                          * 2.00E-07
       1.50E-07 ×
                                                                                          * 1.50E-07
                                                                                          × 1.00E-07
       1.00E-07 ×
       5.00E-08 ×
                                                                                           × 5.00E-08
       5.68E-14 ×
                                                                                           × 5.68E-14
     -5.00E-08 ×
                                                                                          *-5.00E-08
     -1.00E-07 ×
                                                                                          ×-1.00E-07
     -1.50E-07 ×
                                                                                          *-1.50E-07
                                                                                          ×-2.00E-07
      -2.00E-07 ×
                      LOT
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : VIO(T1) VS TIME		TIME	PRINTED : 3.37.18	
TYPE =CA741 IF	DEGC IS 25 IF SUMID IS VIOTREN OR AE50A01 OR AH50A01 OR AI50A0		AK50A01	
TREND PLOT FOR:	TYPE = CA741 TEST = 32 PARAMETER:	_DCD1	•	
LEGEND: /MED	=X/17% = /84% = /	1 311	•	
CELL WIDTH: 1. 2.00E-07 ×			× 2.0	00E-07
2.000	•			,,,,
•			•	
•	•			
1.50E-07 ×			* 1.5	50E-07
•	•		:	
•	•		•	
1.00E-07 ×	•		× 1.0	00E-07
•	•		•	
•	•		•	
:				
5.00E-08 ×			* 5.0	80-30C
	•		•	
•	•		•	
5.68E-14	•		* 5.6	8E-14
•	•		•	
	•		:	
-5.00E-08 >	•		¥-5 (00E-08
-3.006-00				, U.L. 105
•	•		•	
•	•		•	
-1.00E-07 >	•		×-1.6	B0E-07
	•		•	
•	•		•	
-1.50E-07			×-1.5	50E-07
	•		•	
•	•		•	
	•		· 	
-2.00E-07 i	X		X-2.(00E-07
LOT	AA50A01 AE50A01 AH50A01 A	150A0	1 AK50A01	

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                         TIME PRINTED: 3.37.18
TREND PLOT FOR: TYPE
                              = CA741
                                  33 PARAMETER: CMRR
                   TEST
LEGEND: /MED =X/17:
CELL WIDTH: 2.00E-02
4.00E-01 *
                     =X/17%
                               MULTIPLE: >
                                                                                  * 4.00E-01
      3.00E-01 *
                                                                                  * 3.00E-01
      2.00E-01 ×
                                                                                  * 2.00E-01
      1.00E-01 *
                                                                                  * 1.00E-01
                                                                                  * 5.96E-08
      5.96E-08 ×
     -1.00E-01 ×
                                                                                  *-1.00E-01
     -2.00E-01 ×
                                                                                  *-2.00E-01
                                                                                  *-3.00E-01
     -3.00E-01 *
     -4.00E-01 *
                                                                                  *-4.00E-01
                    LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AK50A01

Y=MED OR 17% OR 84%
                                                            TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE = TEST = LEGEND: /MED = X/17%
                            = CA741
= 34 PARAMETER: VIO(ADJ)+
17% = 1/84% = 1/
LEGEND: /MED =X/17%
CELL WIDTH: 5.00E-01
                                MULTIPLE: >
      0.0
     -2.50E+00 ×
                                                                                       *-2.50E+00
     -5.00E+00 ×
                                                                                       ×-5.00E+00
                                                                                       *-7.50E+00
     -7.50E+00 ×
     -1.00E+01 ×
                                                                                       *-1.00E+01
                                                                                       ×-1.25E+01
     -1.25E+01 ×
     -1.50E+01 ×
                                                                                       *-1.50E+01
                                                                                       ×-1.75E+01
     -1.75E+01 ×
                                                                                       ×-2.00E+01
     -2.00E+01 ×
                     LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                               TIME PRINTED : 3.37.18
                                 = CA741
= 35 PARAMETER: VIO(ADJ)-
= | /84% = | /
MULTIPLE: >
TREND PLOT FOR: TYPE
                     TEST = = X/17%
LEGEND: /MED =X/17
CELL WIDTH: 5.00E-01
2.00E+01 *
                                                                                            × 2.00E+01
                                                                                            * 1.75E+01
       1.75E+01 ×
       1.50E+01 ×
                                                                                            * 1.50E+01
                                                                                            × 1.25E+01
       1.25E+01 ×
                                                                                            * 1.00E+01
       1.00E+01 ×
                                                                                            × 7.50E+00
       7.50E+00 ×
                                                                                            * 5.00E+00
       5.00E+00 ×
                                                                                            × 2.50E+00
       2.50E+00 ×
       0.0
                       LOT
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 VIO(T1) VS TIME	TIME PRINTED : 3.37.18
TYPE =CA741 IF DEGC IS 25 IF SUMID IS LOT =AA50A01 OR AE50A01 OR AH50A01 O Y=MED OR 17% OR 84%	VIOTREND R AI50A01 OR AK50A01
TREND PLOT FOR: TYPE = CA741 TEST = 36 PAR	AMETER: ICC
LEGEND: /MED =X/17% = /84% CELL WIDTH: 9.50E-05 MULTIPLE: >	= 1/
3.80E-03 ×	* 3.80E-03
<u>:</u>	:
3.32E-03 *	* 3.32E-03
• •	:
•	•
2.85E-03 ×	* 2.85E-03
: :	:
2.37E-03 *	¥ 2.37E-03
:	•
1.90E-03 *	* 1.90E-03
1.905-03 *	* 1.905-03
:	:
1.43E-03 *	× 1.43E-03
:	÷
9.50E-04 ×	× 9.50E-04
•	•
· ·	• •
4.75E-04 ×	* 4.75E-04
•	•
0.0 ×	
LOT ÄÄŠÖÄÖİ ÄËSÖÄÖİ ÄHS	OAO1 AI5OAO1 AK5OAO1

Fig. IV-13 - Trend analysis (continued).

```
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AK50A01
Y=MED OR 17% OR 84%
                            = CA741
= 37 PARAMETER: IOS+
=|/84% =|/
MULTIPLE: >
TREND PLOT FOR: TYPE
                  TEST
=X/17%
LEGEND: /MED =X/17
CELL WIDTH: 1.50E-04
0.0 *
                                                                              × 0.0
    -7.50E-04 ×
                                                                              ¥-7.50E-04
    -1.50E-03 ×
                                                                              *-1.50E-03
    -2.25E-03 *
                                                                              ×-2.25E-03
    -3.00E-03 ×
                                                                              *-3.00E-03
    -3.75E-03 ×
                                                                              ×-3.75E-03
    -4.50E-03 ×
                                                                              ×-4.50E-03
    -5.25E-03 ×
                                                                              ×-5.25E-03
    -6.00E-03 ×
                                                                              *-6.00E-03
                   LOT
```

TIME PRINTED : 3.37.18

DATE PRINTED : 07/18/81

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81
                                                   TIME PRINTED : 3.37.18
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AK50A01
Y=MED OR 17% OR 84%
                          = CA741
= 38 PARAMETER: IOS-
=|/84% =|/
MULTIPLE: >
TREND PLOT FOR: TYPE
                  TEST
LEGEND: /MED =X/17
CELL WIDTH: 1.50E-03
                  =X/17%
     6.00E-02 ×
                                                                           * 6.00E-02
     5.25E-02 ×
                                                                           * 5.25E-02
     4.50E-02 ×
                                                                           * 4.50E-02
     3.75E-02 ×
                                                                           × 3.75E-02
     3.00E-02 ×
                                                                           × 3.00E-02
     2.25E-02 ×
                                                                           ¥ 2.25E-02
     1.50E-02 ×
                                                                           * 1.50E-02
     7.50E-03 ×
                                                                           * 7.50E-03
     3.73E-09 ×
                                                                          × 3.73E-09
                 LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                          TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE
                              = CA741
                   TEST = 39
=X/17% = 1/84%
LEGEND: /MED = X/17%
CELL WIDTH: 1.00E-03
1.93E+01 *
                                                  =11
                               MULTIPLE: >
                                                                                    * 1.93E+01
      1.93E+01 ×
                                                                                    * 1.93E+01
                                                                                    × 1.93E+01
      1.93E+01 ×
      1.93E+01 ×
                                                                                    * 1.93E+01
      1.93E+01 ×
                                                                                    * 1.93E+01
      1.93E+01 ×
                                                                                    × 1.93E+01
      1.93E+01 ×
                                                                                     × 1.93E+01
      1.93E+01 ×
                                                                                    * 1.93E+01
       1.93E+01 ×
                                                                                    × 1.93E+01
                    LOT
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : VIO(T1) VS TIM			TIME	PRINTED :	3.37.18
TYPE =CA741 IF	DEGC IS 25 IF OR AE50A01 OR			AK50A01	
TREND PLOT FOR					
LEGEND: /MED	=X/17%	40 = /84%	= /		
CELL WIDTH: 4 -1.78E+01		TIPLE: >			¥-1.78E+01
	•				•
	•				•
-1.78E+01	×				¥-1.78E+01
	•				•
	·		•	•	· ·
-1.78E+01	•				x-1.78E+01
	: 1	ļ		1	•
-1.78E+01	×			×	*-1.78E+01
				1	•
	i ķ	į	X I	Ý	•
-1.78E+01	*	,			×-1.78E+01
	:	į			•
	:			1	•
-1.79E+01	* .				×-1.79E+01 ·
	:				•
-1.79E+01	×			•	×-1.79E+01
200,72,02	•	•	•		•
					•
-1.79E+01	×			•	×-1.79E+01
	•				•
	•				•
-1.79E+01	*	×	×	.x	×-1.79E+01
LOT	AA50A01 AES	0A01 AH50	AO1 AISOAO	1 AK50A01	-

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE = CA741 IF DEGC IS 25 IF SUMID IS VIOTREND

LOT = AA50A01 OR AE50A01 OR AH50A01 OR AK50A01

Y=MED OR 17% OR 84%
                                                  TIME PRINTED : 3.37.18
= 1 /
                                                                         * 1.91E+01
      1.91E+01 ×
                                                                         × 1.91E+01
      1.91E+01 ×
                                                                         × 1.91E+01
      1.91E+01 ×
                                                                         × 1.91E+01
      1.91E+01 ×
                                                                         * 1.91E+01
      1.91E+01 ×
                                                                         * 1.91E+01
      1.91E+01 ×
                                                                         × 1.91E+01
      1.91E+01 ×
                                                                         × 1.91E+01
      1.91E+01 ×
                                                                         * 1.91E+01
                 LOT
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : VIO(T1) VS TIME					ME	PRINTED	: 3.37	. 18
TYPE =CA741 IF LOT =AA50A01 C Y=MED OR 17	DEGC IS 2 DR AE50A01	25 IF SUI L OR AHS	MID IS V 0A01 OR	IOTREND A150A01	OR	AK50A01		
TREND PLOT FOR	TYPE	= CA741	_					
LEGEND: /MED CELL WIDTH: 1.	TEST =X/17% 00E-02	= 4 = /: MULTIP	84%	= /				
-1.74E+01 >								¥-1.74E+01
•								•
-1.74E+01 >	•							: *-1.74E+01
	•							
•								•
-1.75E+01	· E							×-1.75E+01
•								•
						i		
-1.75E+01 >		•				1		*-1.75E+01
•			1			X I		•
-1.76E+01	,	(X I	X			X	*-1.76E+01
•								
•						1		•
-1.76E+01 →						1		*-1.76E+01
•				•			•	•
-1.77E+01	I							*-1.77E+01
:								•
•								•
-1.77E+01 ×								×-1.77E+01
. 1.//2.01	ŀ							
	ı							•
-1.78E+01								*-1.78E+01

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                               TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE
                                 = CA741
                      TEST
=X/17%
                                       45
=|/84%
LEGEND: /MED =X/179
CELL WIDTH: 2.00E-03
2.24E-01 *
                                  MULTIPLE: >
                                                                                           × 2.24E-01
      2.14E-01 ×
                                                                                           × 2.14E-01
      2.04E-01 ×
                                                                                           * 2.04E-01
      1.94E-01 ×
                                                                                           × 1.94E-01
      1.84E-01 ×
                                                                                           × 1.84E-01
       1.74E-01 ×
                                                                                           * 1.74E-01
       1.64E-01 ×
                                                                                             1.64E-01
      1.54E-01 ×
                                                                                           × 1.54E-01
      1.44E-01 ×
                                                                                           × 1.44E-01
                      AA50A01 AE50A01 AH50A01 AI50A01 AK50A01
        LOT
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 VIO(T1) VS TIME	TIME PRINTED : 3.37.18	
TYPE =CA741 IF DEGC IS 25 IF SUMID IS LOT =AA50A01 OR AE50A01 OR AH50A01 OF Y=MED OR 17% OR 84%	VIOTREND R AI50A01 OR AK50A01	
TREND PLOT FOR: TYPE = CA741 TEST = 46		
LEGEND: /MED =X/17% = 1/84%	= /	
CELL WIDTH: 1.00E-03 MULTIPLE: > -1.76E-01 *	×-1.7€	5E-01
•	:	
• •	•	
-1.81E-01 ×	×-1.81	1E-01
•	:	
-1.86E-01 *	×-1.86	6F-01
:		
-1.91E-01 ×	×-1.91	1E-01
:	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	
-1.96E-01 *	X *-1.96	5E-01
:		
-2.01E-01 ×	×-2.0	1E-01
.		
-2.06E-01 ×	×-2.00	6E-01
:	:	
·	· 	
2.11E-01 * .	*-2.1	16-01
•	•	
-2.16E-01 ×	×-2.10	6E-01
	×	

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                          TIME PRINTED: 3.37.18
TREND PLOT FOR: TYPE
                              = CA741
                            = 47
|X = |/84X
                  TEST =
=X/17%
LEGEND: /MED =X/17%
CELL WIDTH: 2.00E-04
1.30E-02 *
                               MULTIPLE: >
                                                                                     * 1.30E-02
      1.20E-02 ×
                                                                                     × 1.20E-02
      1.10E-02 ×
                                                                                     × 1.10E-02
      1.00E-02 ×
                                                                                     × 1.00E-02
      9.00E-03 ×
                                                                                     × 9.00E-03
      8.00E-03 ×
                                                                                     * 8.00E-03
      7.00E-03 ×
                                                                                     × 7.00E-03
      6.00E-03 ×
                                                                                     × 6.00E-03
      5.00E-03 ×
                                                                                    × 5.00E-03
                    LOT
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07/18/81 VIO(T1) VS TIME	TIME	PRINTED	: 3.37.18
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIO LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI Y=MED OR 17% OR 84%	TREND 50A01 OR	AK50A01	
TREND PLOT FOR: TYPE = CA741 TEST = 48			
LEGEND: /MED =X/17% = /84% = . CELL WIDTH: 2.00E-04 MULTIPLE: >	•		
6.00E-03 *			* 6.00E-03 ·
:			•
5.00E-03 ×			× 5.00E-03
:			
4.00E-03 * X			× 4.00E-03
:			
			: : X * 3.00E-03
3.00E-03 * X			3.000
<u>:</u>	į		
2.00E-03 *	İ	İ	* 2.00E-03
:			• •
1.00E-03 ×	! X	X	* 1.00E-03
:			•
-3.73E-09 *	İ	İ	: *-3.73E-09
:	•		•
-1.00E-03 ×			×-1.00E-03
:			•
-2.00E-03 *	×	.×	.×
LOT AASOAO1 AESOAO1 AHSOAO1	AI50A0	1 AK50A0	1.

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                         TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE
                              = CA741
= 59
= 1/84%
                    TEST
LEGEND: /MED =X/17
CELL WIDTH: 1.00E-03
2.09E-01 *
                     =X/17%
                                                  =1/
                               MULTIPLE: >
                                                                                   * 2.09E-01
      2.04E-01 ×
                                                                                   × 2.04E-01
      1.99E-01 ×
                                                                                   × 1.99E-01
      1.94E-01 ×
                                                                                   * 1.94E-01
      1.89E-01 ×
                                                                                   × 1.89E-01
      1.84E-01 ×
                                                                                   * 1.84E-01
      1.79E-01 ×
                                                                                   * 1.79E-01
      1.74E-01 ×
                                                                                   * 1.74E-01
      1.69E-01 ×
                                                                                   * 1.69E-01
                    LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81
                                                      TIME PRINTED : 3.37.18
VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND

LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01

Y=MED OR 17% OR 84%
TREND PLOT FOR: TYPE
                             = CA741
                                 60
=|/84%
                   TEST
LEGEND: /MED = X/17
CELL WIDTH: 1.00E-03
-2.31E-01 ×
                    =X/17%
                                               = ] /
                              MULTIPLE: >
                                                                               *-2.31E-01
     -2.36E-01 ×
                                                                               *-2.36E-01
     -2.41E-01 ×
                                                                               *-2.41E-01
     -2.46E-01 ×
                                                                               *-2.46E-01
     -2.51E-01 ×
                                                                               ×-2.51E-01
     -2.56E-01 ×
                                                                               *-2.56E-01
     -2.61E-01 ×
                                                                               *-2.61E-01
     -2.66E-01 ×
                                                                               *-2.66E-01
     -2.71E-01 ×
                                                                               *-2.71E-01
                   LOT
```

THE PARTY OF THE PARTY NAMED IN

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED: VIO(T1) VS TIME TYPE =CA741 IF		IID IS VIOTREN		D: 3.37.18
LOT =AA50A01 0	R AE50A01 OR AH50	AOI OR AISOAC	I OR AK50A0	1
TREND PLOT FOR:	TYPE = CA741 TEST = 61			
LEGEND: /MED CELL WIDTH: 2.0 2.30E-02 *	=X/17% = /8 00E-04 MULTIPL			* 2.30E-02
:				•
2.20E-02 *	1			* 2.20E-02
				:
2.10E-02 *				* 2.10E-02 :
2.00E-02 *				* 2.00E-02
:				
1.90E-02 *	× 			X × 1.90E-02
1.80E-02 ×		× ×	×	: * 1.80E-02
:				
1.70E-02 ×				¥ 1.70E-02
1.60E-02 *		1 ('	* 1.60E-02 :
1.50E-02 ×	y.	<u>u</u>	y.	× 1.50E-02
LOT	AA50A01 AE50A01	~ AH50A01 AI	ŠÖÄÖİ ÄKŠÖ	.

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : 07 VIO(T1) VS TIME	7/18/81	TIME	PRINTED :	3.37.18
TYPE =CA741 IF DE	EGC IS 25 IF SUMID IS AE50A01 OR AH50A01 (OR 84%	S VIOTREND DR AI50A01 OR	AK50A01	
TREND PLOT FOR: 1	111 T			
LEGEND: /MED CELL WIDTH: 2.00	TEST = 62 =X/17% = /84% OE-04 MULTIPLE: >	=(/		
4.40E-03 ×				× 4.40E-03
•				•
7 405 07 1				
3.40E-03 ×				* 3.40E-03
•				
2.40E-03 ×			İ	* 2.40E-03
		Ì	1	× 2.40E-03
•		}		
1.40E-03 ×				× 1.40E-03
•	i i	į ×		x :
•	î î	Î		î :
4.00E-04 ×				× 4.00E-04
•			i X	!
•	, ,	İ	Î	•
-6.00E-04 ×		Ì	İ	×-6.00E-04
•		ļ		•
•				•
-1.60E-03 ×		Ì		×-1.60E-03
:		1	i	•
•				•
-2.60E-03 ×				*-2.60E-03
•				•
-7 4AP AP 2			*1	
-3.60E-03 ×	<u> </u>	.	. x	*-3.60E-03
LOT A	AA50A01 AE50A01 AH	50A01 A150A01	L AK50A01	

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED : 07/18/81
                                                    TIME PRINTED : 3.37.18
TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%
TREND PLOT FOR: TYPE
                            = CA741
                  TEST
=X/17%
                                  70
LEGEND: /MED =X/17:
CELL WIDTH: 1.00E-04
3.10E-03 *
                                =1/84%
                                             = 1/
                            MULTIPLE: >
                                                                            × 3.10E-03
      2.60E-03 ×
                                                                            × 2.60E-03
      2.10E-03 ×
                                                                            * 2.10E-03
      1.60E-03 ×
                                                                            × 1.60E-03
      1.10E-03 ×
                                                                            × 1.10E-03
      6.00E-04 ×
                                                                            * 6.00E-04
      1.00E-04 ×
                                                                              1.00E-04
    -4.00E-04 ×
                                                                            ×-4.00E-04
                                                                           ×-9.00E-04
    -9.00E-04 ×
                  LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01 Y=MED OR 17% OR 84%
                                                           TIME PRINTED : 3.37.18
                               = CA741
= 71
= 1/84%
TREND PLOT FOR: TYPE
                  TEST
LEGEND: /MED =X/17:
CELL WIDTH: 1.00E-03
5.60E-01 *
                     =X/17%
                                                   =1/
                                MULTIPLE: >
                                                                                      × 5.60E-01
                                                                                      × 5.55E-01
      5.55E-01 ×
                                                                                      × 5.50E-01
      5.50E-01 ×
      5.45E-01 ×
                                                                                      × 5.45E-01
      5.40E-01 ×
                                                                                      × 5.40E-01
      5.35E-01 ×
                                                                                      × 5.35E-01
                                                                                       × 5.30E-01
       5.30E-01 ×
                                                                                      × 5.25E-01
       5.25E-01 ×
       5.20E-01 ×
                                                                                      * 5.20E-01
                     LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND

LOT =AA50A01 OR AE50A01 OR AH50A01 OR AK50A01

Y=MED OR 17% OR 84%
                                                          TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE
                               = CA741
                    TEST = = X/17%
                              = 72
= |/84%
LEGEND: /MED =X/175
CELL WIDTH: 1.00E-03
1.11E+00 *
                                                   =|/
                                MULTIPLE: >
                                                                                     × 1.11E+00
      1.10E+00 ×
                                                                                     * 1.10E+00
      1.10E+00 ×
                                                                                     * 1.10E+00
      1.09E+00 ×
                                                                                     × 1.09E+00
      1.09E+00 ×
                                                                                     × 1.09E+00
      1.08E+00 ×
                                                                                     × 1.08E+00
      1.08E+00 ×
                                                                                     × 1.08E+00
      1.07E+00 ×
                                                                                     × 1.07E+00
      1.07E+00 ×
                                                                                     × 1.07E+00
                    LOT
```

ţ.

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND
LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01
Y=MED OR 17% OR 84%
                                                           TIME PRINTED : 3.37.18
TREND PLOT FOR: TYPE
                               = CA741
                    TEST
=X/17%
                                    93
=|/84%
LEGEND: /MED =X/17
CELL WIDTH: 2.00E-09
2.40E-07 *
                                                   =1/
                                MULTIPLE: >
                                                                                      × 2.40E-07
       2.30E-07 *
                                                                                      × 2.30E-07
                                                                                      × 2.20E-07
       2.20E-07 ×
       2.10E-07 ×
                                                                                      * 2.10E-07
                                                                                      × 2.00E-07
       2.00E-07 ×
                                                                                      × 1.90E-07
       1.90E-07 ×
                                                                                      × 1.80E-07
       1.80E-07 ×
                                                                                      × 1.70E-07
       1.70E-07 ×
       1.60E-07 ×
                                                                                      × 1.60E-07
                     LOT
```

Fig. IV-13 - Trend analysis (continued).

```
DATE PRINTED: 07/18/81 TIME PRINTED VIO(T1) VS TIME

TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 OR AK50A01 Y=MED OR 17% OR 84%
                                                               TIME PRINTED : 3.37.18
                     TYPE = CA/41
TEST = 94
=X/17% = |/84%
00E-01 MULTIPLE: >
TREND PLOT FOR: TYPE
LEGEND: /MED =X/17%
CELL WIDTH: 2.00E-01
1.92E+01 *
                                                       = 1/
                                                                                            × 1.92E+01
                                                                                            × 1.82E+01
       1.82E+01 ×
                                                                                            × 1.72E+01
       1.72E+01 ×
       1.62E+01 ×
                                                                                            * 1.62E+01
                                                                                            × 1.52E+01
       1.52E+01 ×
                                                                                            × 1.42E+01
       1.42E+01 ×
       1.32E+01 ×
                                                                                              1.32E+81
                                                                                            × 1.22E+01
       1.22E+01 ×
                                                                                            * 1.12E+01
       1.12E+01 ×
                       LOT
```

Fig. IV-13 - Trend analysis (continued).

DATE PRINTED : VIO(T1) VS TIME	07/18/81 Degc is 25 if SU	IMIN IS VINID	TIME PRINTE	D : 3.37.18
LOT =AA50A01 OF	R AESOAOL OR AHS	0A01 OR A150	. UR AK50A0	1
TREND PLOT FOR:		5		
LEGEND: /MED CELL WIDTH: 4.0 4.60E-06 *	=X/17% = /	84% = 1/		× 4.60E-06
4.00E-06 ×				* 4.00E-00
:				•
4.40E-06 ×				* 4.40E-06
•		. !	!	1 :
4.20E-06 *				¥ 4.20E-06
4.00E-06 *			ļ	4.00E-06
4.00E 00 ×	×		Î	
3.80E-06 ×				: * 3.80E-06
3.60E-06 *				¥ 3.60E-06
•				:
3.40E-06 ×				¥ 3.40E-06
3.20E-06 *	İ	'	•	' : * 3.20E-06
•				•
3.00E-06 ×	.	¥ ¥	*	× 3.00E-06
LOT	AA50A01 AE50A	DÎ AHSOADÎ A	150A01 AK50	AOI

Fig. IV-13 - Trend analysis (continued).

VIO(T1) VS TIME TYPE =CA741 IF DEGC IS 25 IF SUMID IS VIOTREND LOT =AA50A01 OR AE50A01 OR AH50A01 OR AI50A01 Y=MED OR 17% OR 84% TREND PLOT FOR: TYPE = CA741 TEST = 96 LEGEND: /MED = X/17% = 1/84% = 1/ CFLL WIDTH: 1.00E-07 MULTIPLE: >	
TEST = 96 LEGEND: /MED =X/17% =1/84% =1/	
LEGEND: /MED =X/17% =1/84% =1/	
CELL WIDTH: 1.00E-07 MULTIPLE: > # 6.50E-0 6.50E-06 *	6
6.00E-06 *	6
5.50E-06 * * 5.50E-0	6
5.00E-06 ×	6
4.50E-06 × × 4.50E-0	6
4.00E-06 * * 4.00E-0	16
3.50E-06 × × 3.50E-0	16
3.00E-06 × × 3.69E-6	16
2.50E-06 × × 2.50E-0	16
LOT AASOAOI AESOAOI AHSOAOI AISOAOI AKSOAOI	. •

Fig. IV-13 - Trend analysis (continued).

Distribution List for Quarterly and Final Report N00039-76-C-0240

Naval Electronic Systems Command		Naval Research Laboratory		
Code 30421 - R. A. Wade		Code 5210 - J. Davey		
Washington, DC 20360	2	Washington, DC 20375	1	
Naval Research Laboratory		Naval Electronics Laboratory C	enter	
Code 5261 - D. Patterson		Code 4300 - C. E. Holland		
Washington, DC 20375	1	San Diego, CA 92152	1	
Naval Electronics Laboratory Cent	er	Naval Electronics Laboratory C	enter	
Code 4800 - D. McKee		Code 743 - E. Urban		
San Diego, California 92152	1	San Diego, CA 92152	1	
DCASD, Springfield		Naval Weapons Support Center		
240 Route 22		Code 7024 - R. Freeman		
Springfield, N.J. 07081	1	Crane, Indiana 47522	1	
US Army Electronics Command		Rome Air Development Center		
Code AMSEL-TL-IR - E. Hakim		Code RADC/RBR - J. Bart		
F. Monmouth, N.J.	1	Griffiss AFB, NY 13441	1	
Naval Surface Weapons Center		Defense Documentation Center		
Code WA33 - A Auerbach		Cameron Station		
Silver Springs, MD 20910	1	Alexandria, VA 22314	1	
Advisory Group on Electron Device	s	Director, Army Production Equi	pment	Agency
201 Varick Street, 9th Floor		Att: DRXPE-MT (McBurney)	-	- •
New York, N.Y. 10014	1	Rock Island, Ill. 61201	1	

AIE LME